## The Manufacture of Open-Hearth Steel.

*On Recent Improvements in the Method of the Manufacture of Open-Hearth Steel.**

BY MR. JAMES RILEY, GLASGOW.

Early in the year 1875, in a report I then prepared with reference to Siemens Steel Works, I made the following remarks: "I am desirous of stating what I hold necessary to be done in order to keep abreast with the Bessemer steel makers in this and other countries. I am convinced that, with existing arrangements and appliances, very little, if any, further economy in manufacture can be accomplished; and I am doubtful if we are not even now beaten by other manufacturers, with the certainty that this will be the case when the improvements now being gradually adopted by the Bessemer manufacturers are more fully and perfectly realized. Feeling this, I take it to be a matter of life or death to the company that many and extensive alterations should be at once adopted; and I have given much anxious thought to the question of what should be done in this serious emergency."

At that time nearly the whole of the steel made by the Siemens process was used in the making of rails, and I undertook that if my proposals were adopted I would reduce the then cost of rails by about £1 per ton. Unfortunately this could not be done, and we had a lingering, miserable existence until the introduction of ferro-manganese by our French friends enabled us to turn our attention to the production of special classes of steel—first plates, angles, etc., for use in ship, bridge, and boiler construction, and next material to be used in substitution of the best charcoal iron, then solely used in the manufacture of the finest qualities of tin plates. I need not refer at this time to all the many and varied obstacles with which we had to contend in introducing what used to be called the "new material;" many of them have been more or less made known to you in the past years. Suffice it to say, that the enormous growth of the consumption of "mild steel" for these and other purposes enabled the makers of Siemens steel to abandon the unprofitable manufacture of rails for the remunerative one of which I have just spoken; but earlier in our history there was no other outlet for our steel.

At that time each furnace had a large staff of highly paid men to work it, and yet it was considered very good work indeed when 50 tons of ingots were made in one week even at the newer and larger furnaces. The total cost of labor in the melting shop (including the labor at the gas-producing works) was not less than 14s. per ton on the ingots made. My desire was to largely reduce this excessive cost of labor, as the cost of repairs, the consumption of fuel, and the standing charges; and I expected to accomplish my purpose by remodelling the shop and other arrangements for working, by largely increasing the capacity of the melting furnace, and consequently, it was hoped, its productive power. As I have said, circumstances, did not then admit of the proposed changes being carried into effect, but in the following years some of these proposals were carried out (both by myself and others,) and my expectations were more than realized. With a modern 12-ton Siemens furnace, "good work" requires that 140 tons to 150 tons of ingots shall be made weekly per furnace, while in some "special" cases the make has reached 200 tons of ingots in one week from one furnace.

It is perhaps superfluous for me to add that the result of all this was that, on the whole, the makers of Siemens steel had for a time a fairly remunerative business.

Recently, however, the demand for these products has been more than equalled by the largely increased and increasing powers of production, and the competition for the business offering has been so keen that the margin of profit, becoming gradually narrowed during the last two or three years, has now almost, if not entirely disappeared.

At our last meeting in London, in the course of discussion on a kindred topic, we were told that if "skill and brains" were brought to bear on our operations, the cost of making steel plates, etc., could be so reduced that we should, by selling more cheaply, create such an increased demand that all our works would be kept full constantly, and, it might be, profitably employed.

That our brain shave been sorely exercised during the last anxious year or two "goes without saying," but it is not for me to say whether the needful "skill" has been exercised as well.

I have already referred in brief terms to the improvements made by ourselves at our Newton Works, and by others in the erection of the newer works called into existence by the great demand for "mild steel." I would now direct your attention to the more recent efforts in the direction of improvements in which I have been anxiously engaged.

The remodelling of the Blochairn Works, after they were acquired by the Steel Company of Scotland, gave us the opportunity of embodying in our newer practice the results of our previous experience at Newton, more especially in the melting department which had to be created. My first plans were for a shop with twenty 12-ton furnaces, afterwards modified to twelve 15-ton furnaces. I had for some time been extremely anxious to try the "Pernot" furnace, in which I thought I recognised the means by which we—open-hearth steelmakers—might most readily avail ourselves of the basic process, then exciting so much attention, and causing some of us so much anxiety. Now the opportunity offered, and the first furnaces erected were two 20-ton Pernot's. These were hurried on as quickly as possible, so that by the results obtained from them I might be guided in deciding what type of furnace should be adopted for the whole shop. They were fine furnaces, admirably designed and constructed, as we had the advantage of some drawings given me by our lamented friend Mr. Holley. The mechanical arrangements were perfect, but the results were not satisfactory, I have never felt satisfied with the results of those trials, but in our then circumstances I was compelled to stop them after three months' trial, and we proceeded to erect, as rapidly as possible, Siemens furnaces, as perfect in every respect as we could make them.

Perhaps, as I am speaking of furnaces, it will be most convenient for me to state that in 1880 we made experiments, extending over some weeks, with a Siemens furnace lined with basic material, under the personal superintendence of Messrs. Thomas & Gilchrist. We had to abandon the process principally on account of the difficulties and trouble caused by the fluxing of the lining at the lines of division of the basic and acid material, in spite of every precaution then possible to us.

I may also state that for some months past we have had at work furnaces of the type known as the "Batho" furnace; and although time is required for the realization of all the economies promised by the inventors, yet we have been so satisfied with the suitability to our circumstances that my directors have arranged for a few more to take the places of the older Siemens furnaces which now require to be renewed.

In this connection I may also be allowed to call attention to a valuable modification of the Siemens furnace, known to us as the "Hackney" port. So satisfied are we of the advantages derived from its use that this modification will be made at all our melting furnaces as they are stopped for repairs.

I need not make any special reference to another type of furnace which we have had in use for some months, as it is to form the subject of a special paper by Mr. Dick.

As I have already indicated, we erected at Blochairn a row of twelve 15-ton furnaces; the ingots were cast in one long pit, parallel to, and close in front of the furnaces, the tops of the ingots being level with the general floor, so that bogies or wagons could be rapidly passed to other departments. The charging floor was, of course, at a higher elevation, approached by a slight incline at one end of the shop.

We had so fully realized at Newton the serious disadvantage and loss due to the relative positions of the hammers and mills and the melting shop, that we were constantly devising the schemes to obviate them.

At Blochairn I made these relative positions such as would, I hoped, enable us to transfer the ingots from the casting pits to the hammers at temperature that would perhaps allow us to dispense with reheating, or at all events to reduce this reheating to a minimum. My hopes were not fulfilled. When we tried to hammer the ingot with only its initial heat, we either found the centre too soft (and it would spurt out when struck by the hammer), or, on the other hand, the outside was so cold and hard that it cracked, and the slab could only be rolled into a defective plate.

With regard to the charging of the ingots hot into the reheating furnace, my purpose was to a large extent frustrated by what may seem a trivial cause, but yet one which, in reality, was very difficult to deal with.

The twelve melting furnaces were so many independent centres of operation. The men came in on Sunday night and charged their furnaces all at the same time, with about the same weight of charge, and as a matter of course all of them were ready for tapping about the same time on the Monday morning, and all through the succeeding week, except in so far as this was affected by the slight variations in the speed at which the furnaces were working. Thus we would have the whole of the furnaces cast within a short time of each other, and a crowding of ingots to the reheating furnaces; then a long pause of twelve or fourteen hours, followed by another rush of casting. During the pause the ingots were, of course, getting cold, and as they were of large size, this was a serious matter, not alone on account of the cost of reheating them, but because of the cracks which were set up both in the course of cooling and reheating.

It is obvious that the cure for all this was to make the furnaces charge and cast in succession; but there were many reasons why this could not be done at that time: into these I need not now enter.

I have said that we were incessantly at work on this matter of preventing the ingots getting cold, especially at Newton, where we suffered more than at Blochairn. At last I devised and experimented with what I may term a moveable set of soaking pits for conveying the ingots to the hammers shortly after they were cast. By this means I was able to accomplish the hammering of the ingots into slabs without reheating. Subsequently, however, my directors authorized me to arrange with Mr. Gjers for the use of his patent soaking pits, and the outcome of this decision has been the practical remodelling of all our working arrangements, which I will presently describe.

Our first intention was to put the soaking pits down in convenient relation to the hammers at one end of the melting shop, but further consideration led me to determine against this course. For two years or so previously we had been cogging part of the slabs for plates as a matter of necessity, as we had not sufficient hammer power at Blochairn to meet all demands. We had found the plates made from cogged slabs equal to those

* Paper read at the Chester Meeting of the Iron and Steel Institute.

made from hammered slabs, and with proper mechanical arrangement we saw that we could make the former at a somewhat less cost than the latter, especially in the case of very heavy slabs, Further, on many occasions I had serious difficulties with the hammermen. Now, having arrived at a crisis, I determined, as far as possible, to substitute cogging for hammering.

The most convenient position for the proposed new cogging mill and soaking pits seemed to be about the centre of the line of melting furnaces, where, fortunately, there was an available engine of about sufficient power to work the mill. When, however, we came to consider the mode of working, I saw that the crucial point was the delivering of the ingots to the soaking pits in something like regular succession, and I was again brought face to face with the old difficulty regarding the casting of the furnaces, as well as with the difficulty of conveying the ingots from the casting to the soaking pits. We gave a great deal of thought to this matter, and I had some conversation thereon with Mr. Gjers. At last it was decided that it would be better to make one central casting pit for all the furnaces, with the object of compelling successions of casting, and of avoiding the necessity for carrying the ingots. This decision also enabled me to accomplish another long desired end, which was to obtain the advantage due to agitating the steel. Failing Mr. Allen's "agitator," which we could not conveniently use in our works, I saw the possibility of adopting the method of pouring from one ladle to another, which had been so successfully inaugurated by Mr. Gjers at Darlington, and this was kept in view as a principal object of the changes and alterations contemplated.

My directors having authorized the carrying out of these proposed changes at both the Newton and the Blochairn Works, and those at the latter (which were not so extensive and difficult as those at Newton) having been about completed, I have now pleasure in directing your attention to the diagrams which show our new arrangements, and of which Fig. 1 is a transverse section or side elevation, Fig. 2 a plan, and Fig. 3 a longitudinal section or elevation of the melting-shop at the Blochairn Works.

The twelve melting furnaces are designated by the letters A to M inclusive; the M furnace is sufficiently large to hold a charge of 25 tons, all the rest are known as 15-ton furnaces. In front of and parallel to the furnaces are lines of railway, of which the nearest runs over the old casting pit, which has been filled up except at a few points where it has been left open as provision for casting in the case of any accident to the machinery in the new arrangements. On this railway runs a small locomotive, which moves from point to point in front of the furnace, a special carriage conveying a ladle for the steel and a mould for the slag.

A specially-designed hydraulic lift of 20 tons power is erected between the furnaces E and F and directly over the railway just referred to.

Directly in front of this lift is a 20 ton casting crane of ordinary type, except that it is not made to lift. It is, however, provided with hydraulic engines for turning it on its axis, and also carries on one side a small cylinder and ram for turning over the casting ladle after each cast, so that any slag or skull may be easily cleared out and the nozzle pot may be readily changed. This crane is placed in center of a semi-circular casting pit 40 ft. in diameter and about 3 ft. deep.

At convenient points round the casting pit are erected three ingot cranes, each capable of lifting five tons, in two pourers of three tons and two tons each. Between the cranes are two sets of soaking pits, each with six cells of differing capacity for ingots of 30 cwt. or 60 cwt. each.

The two outer cranes set the moulds in the pit ready for casting, and afterwards strip the ingots and deposit them in the soaking pits.

The center crane lifts the ingots from the soaking pits and places them vertically on the tipping carriage at the end of the feed-rollers of the cogging mill. A hydraulic cylinder and ram are placed convenient to this tipping ar-

Fig. 1

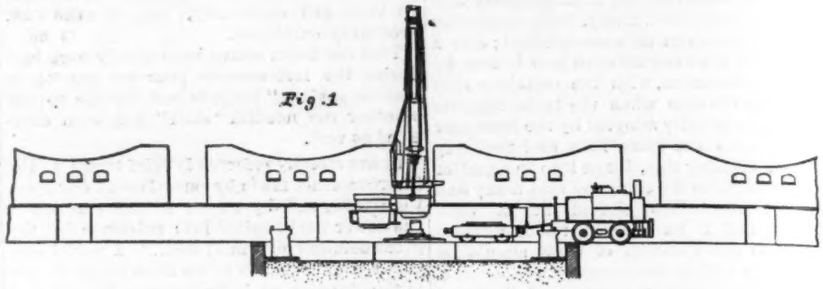


Fig. 2.

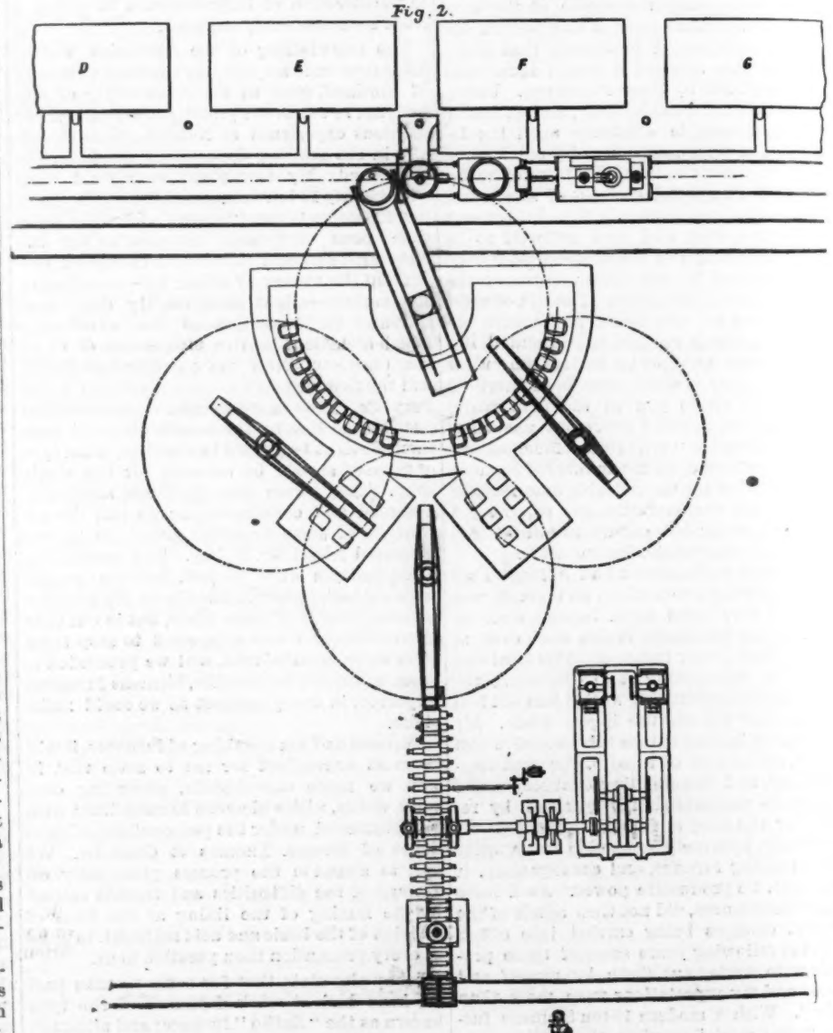
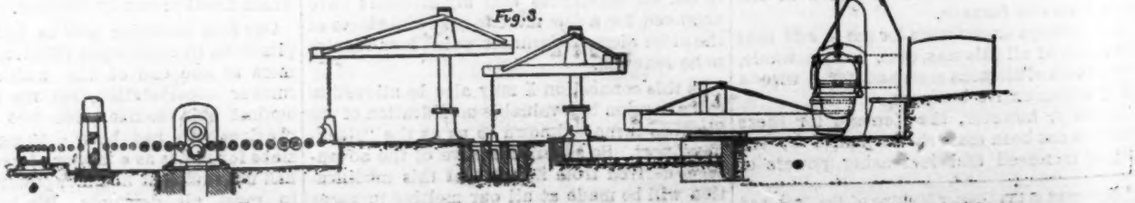



Fig. 3.



THE MANUFACTURE OF OPEN-HEARTH STEEL.

rangement. The ram, taking hold of an arm of the carriage, turns it down, so that the ingot is deposited easily and without shock on the feed-rollers of the mill.

The cogging mill has hollow steel rolls, with 32 in. centers, and having edging grooves at each end, the top roll being balanced by hydraulic power in cylinders placed under the bedplate, and having a lift of 14 in.

Instead of turning the screws in the ordinary manner, the boxes are made to revolve, motion being communicated from a small Willans engine through a shaft carried on the top of the housings, and having two worms taking into wormwheels fixed on the screw boxes.

Between the feed-rollers of the mill are arms designed for handling the ingot, which is turned by them on flat or edge and placed in front of the grooves as may be desired, the arms being actuated by hydraulic cylinders placed under the feed-rollers.

This mill is in charge of and operated by one man, assisted by two boys, one of whom works the screwing gear at the rolls, and the other the turning and the feeding gear.

The mill is driven by an engine with two cylinders, 36 in. in diameter and 4 ft. stroke, and is geared 2¾ to 1. The steam pressure is 90 lb., cut off at three-quarters stroke. The rolls make 28 revolutions per minute, and have a periphery speed of about 180 ft. per minute.

A set of hydraulic shears is in course of construction, having a working pressure of 1000 tons, and calculated to shear slabs 24 in. by 8in. in section. These will be placed behind the mill and will have feed-rollers, which will receive the slab from the mill and pass it on and through the shears to carriages, which convey the slabs to the reheating furnaces of the plate mills.

Having thus described the apparatus, may I now describe the *modus operandi*?

The melting furnaces are charged in rapid succession on the Sunday night, and on one coming ready for tapping (about twelve hours later) the locomotive places the carriages and ladle in front of the furnace the charge is tapped into the ladle, the whole of the steel and slag being run into it, while the latter overflows into the slag mould on the carriage.

By this means we save the steel which ordinarily is found at the bottom of the slags in the pool in front of the furnace, and we have the slag in such a form, and so free from steel, that it is easily disposed of without the necessity of being broken up.

Being brought under the lift, the ladle is raised until certain brackets or horns, placed on each side of its pouring lip, come in contact with brackets, attached to the lift, and so placed that they keep the pouring lip of the ladle in the same horizontal plane until all its contents are discharged into the second or casting ladle, which is easily brought about by continuing the lifting of the ladle after the pouring lip has become stationary in the brackets. The casting crane having received into its ladle the whole contents of the first ladle, is now moved round over the moulds in the casting pit, into which the charge is cast in the ordinary manner.

The time occupied by the operations of tapping the furnace, transferring the steel to the second ladle, and casting into moulds, is fourteen to fifteen minutes, a shorter time than is required by the old method.

You will have noticed that this arrangement for transferring the steel obviated the necessity for a lifting casting crane.

This transferring of the steel was a source of great anxiety to us all. It was known to us that some method of transferring had been tried elsewhere, and had been found impracticable. We also knew that the temperature of Siemens steel is much lower at the time of tapping than is that of Bessemer steel, and it was feared that the charge might be so chilled in the operation that it could not be cast through the nozzle of the second ladle, or that, if this were done at all, a heavy skull would be left in the ladle. Neither of these evil results has been experienced, the fact being that we have less skull now than we had under the old practice. The men know that if they cast their charge short of heat this will inevitably be discovered, and they will suffer; and the ladles, being constantly employed, are kept hotter, so that the first steel poured into the second ladle is very hot, and is not chilled when it falls on the bottom. After standing about 20 minutes from casting, the moulds are stripped and the ingots placed in the soaking pits, where they remain about 55 minutes, being then passed through the cogging mill and reduced to the required section, after which they are sheared to the specified weight and passed on to be reheated and rolled into plates.

It may be said, therefore, that the slab is finished in 95 minutes—14 or 15 minutes for tapping and casting, 20 minutes in the moulds, 55 minutes in the soaking pits, and 5 minutes in cogging and shearing.

The advantages of the new casting arrangements are very considerable. The whole operation is much more under control, and is more methodically carried out; less plant is required in ladles, carriages, travelling cranes, and moulds; the cost in labor is much reduced; the shop is freed from débris, and is cleaner and pleasanter to work in. The advantages of the other portions of the arrangements—the soaking pits and cogging mill—are great in every way. The cost of labor is largely reduced, that of fuel is saved altogther; the loss of steel by reheating is reduced from say 2¾ per cent., to almost *nil*, our returns showing this loss in the soaking pits to be only 0.02 per cent., and in addition, the indirect economies by reason of improved quality of slabs, less defective plates, etc., are more important than you would credit if I were to venture to state them.

Besides this, the comfort and orderliness with which the work can be done is largely increased, and is appreciated by the workmen themselves.

Of the machinery I may state that the cogging mill and gear were made at our own works. The large hydraulic shears are now approaching completion in the hands of Messrs. Tannet, Walker, and Co., who also made the casting and ingot cranes.

I believe I am correct in stating that the latter are the finest and most complete cranes which have yet been made, either by that or any other firm. They have a range of 40 ft. in diameter, and are supplied with hydraulic turning and racking gear, most admirably designed, and I am glad to say that on the whole they have proved satisfactory in operation. The ladle lift was supplied by Messrs. Fielding and Platt, of Gloucester, and is a capital job.

In conclusion, I have only to say that I desire to acknowledge the hearty co-operation and assistance I have constantly received from Mr. Dick (the manager of Blochairn Works) in the course of the extensive and important changes which I have briefly attempted to describe, as well as from Mr. Packer the manager, and Mr. Swaine the engineer, of the Newton Works, in the similar operations now in progress at the latter works.

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THERE is a decided revival in the demand for steel rails, the English makers having sold upwards of 40,000 tons during the week ending Oct. 25th, or fully four times the average weekly sales of the current year. In addition to the above there are large inquiries from both home and foreign railways, who have for a long period purchased only for their immediate requirements. The prospects of this branch of the steel trade would therefore seem to be considerably improved.

## "The Western Division of the Canadian Pacific Railway."[1*]

BY THE LATE J. C. JAMES AND ALLAN MACDOUGALL, M. INST. C. E., F. R. S. E.

The first line of Railway to cross the American continent was the Union Pacific, completed in May 1869, and the construction of this was justly entitled to the praise meted out to it; it was an undertaking of great magnitude, and to a large extent, an experiment. The railroad was built at the rate of 1 mile per day in many portions: this rapidity of work not being confined to short sections, but extending over considerable distances. One of the most surprising circumstances connected with its progress was the rapidity with which track was laid. It was an unequalled engineering success at that time. This road was similar in many respects to the Canadian Pacific Railway; it entered an uninhabited and unexplored country, all labor, supplies for man and beast, and track materials had to come from its eastern end; and, as the line progressed, the field of action was always receding from the base of supplies. On these points there is a common comparison between the two systems. During the working season of 1881 the progress of the Canadian Pacific Railway far excelled that of any railway hitherto built; satisfactory as this was, it was completely eclipsed by the progress affected in 1882.

The Canadian Pacific Railway was originally projected by the Government of the Dominion on the Confederation of the Province of British Columbia in 1871, to give an all-rail route on Canadian Territory. It had also another and equally important project, namely, the colonization of the extensive tracts of fertile land forming the great North-West Territory. Surveys were commenced at once and extended over several years, under the charge of Mr. Sanford Fleming, C. M. G., M. Inst. C. E, who issued several reports on the country and the various projected routes. The line finally determined upon was located 20 miles to the north of what was then called Fort Garry, now the site of the city of Winnipeg, in continuation of the line from Lake Superior. It took a north-westerly direction, passing to the east of Lake Manitoba, and crossing it at the neck of land near its centre; then passing to the west of the lake and south-west of Lake Winnipegoosis, till parallel 52° north latitude was intersected near 101° west longitude. Its route is thence westerly to Fort Edmonton, about 113° 30′ west longitude, 53° 30′ north latitude till it enters the valley of the River Arthabasca, 117° 20′ west longitude, 53° 30′ north latitude; which it follows up to the Yellowhead Pass in the Rocky Mountains, about 118° 45′ west longitude, 52° 50′ north latitude. A good deal of work was done on this track, and the telegraph line erected as for as Fort Edmonton, and operated for several years.

While these explorations were being carried on, the route from Thunder Bay, on Lake Superior, to Selkirk, the point north of Winnipeg already mentioned, was determined, and the contracts were let. Work has been continuous on this division for six or seven years, and this portion of the line is now open for traffic. There are very heavy works and numerous engineering difficulties on this division.

The Pembina branch, which connects Winnipeg with the American railway systems, originally commenced at Selkirk, and follows the right, or east bank, of the Red River to the international boundary in 49° north latitude. By this arrangement Winnipeg would have been on a branch. The works on this branch

[1] Additional information, particularly as to the estimated cost of works, is contained in the following reports which will be found in the Library of the Institution:—"Canadian Pacific Railway: Report of Progress on the Explorations and Surveys up to January, 1874," by Sandford Fleming, Engineer-in-Chief. Also "Report on Surveys and Preliminary Operations up to January 1877;" and Reports 1879 and 1880.

[*] From other Selected Papers of the Institution of Civil Engineers.

are very light; it was graded for its entire length in 1875, but, owing to some difficulties amongst the promoters of the St. Paul, Minneapolis and Manitoba Railroad, the track was not laid till 1878, being completed for that distance in December, and trains commenced to run over it in the spring of the following year. Both these divisions have been built by the Dominion Government, and are to be handed over on completion to the Syndicate as part of of their contract.

The Government in 1880, finding the construction of this enormous system too heavy a burden, advertised for tenders for its construction. In the month of August the final arrangements were completed with the present syndicate, and at a meeting of Parliament in the following month, called together specially for this purpose, the terms were ratified. [2]

As soon as the present Direction obtained possession of the road, they diverted the alignment, taking it much farther to the south. Its general direction is now west for 150 miles from Winnipeg, a little to the south of 50° north latitude; it then runs towards the forks of the Red Deer and South Saskatchewan rivers, about 110° west longitude, 50° north latitude; thence it passes nearly due west to 114° west longitude, where it enters the valley of the Bow River. It follows this valley for 115 miles, and traversing Kicking Horse Pass in the Rocky Mountains, about 117° west longitude, 51° 30′ north latitude, enters the province of British Columbia. This location was adopted to obtain lighter works than those on the Government line, and to open up lands equally good and fertile as those on the other line, and also to strike a new pass in the Rocky Mountains considerably to the south of, and which has a much lower elevation than, Yellowhead Pass. It may here be remarked that a line has been successfully located through this pass, and a junction effected with the Government lines in British Columbia.

As a matter of necessity the whole route of the new lines had to be explored and located ahead of the graders. The length constructed in 1881 was 160 miles, which included the building of an air-line from Winnipeg to Portage-la-Prairie, 55 miles, and the extension of the main line to 30 miles beyond the town of Brandon. These works were under the charge of General Rosser, a Southern engineer.

In 1882 the main line had again to be explored and located ahead of the laborers, during the working season, as it is not practicable to keep survey parties in camp on the prairies in winter. It is the progress of these works the authors wish to bring under the notice of the Institution, as they believe they are unequalled and unexampled in the history of railway building. General Rosser having resigned in the spring of 1882, Mr. J. C. James was appointed Chief Engineer, and operations were carried on under his direction. During the season, extending from the 1st of June to the 1st of December, embracing a period of one hundred and fifty-seven working days, 411 miles of main line were built, 388 miles of track laid and opened for traffic; or, with side tracks, 418 miles of track were laid, and a branch 114 miles long was also built and opened for traffic. Between the 1st of April and the 1st of December survey parties located 620 miles on the plains. The distances from Winnipeg to the—

| | Miles. |
|---|---|
| End of located line | 840 |
| " grading | 633 |
| " track-laying | 555 |
| Crossing River Saskatchewan | 661 |
| End of 500-mile contract | 667 |

A length of 15 miles more was graded in various places between the end of the continuous grade and the River Saskatchewan.

[2] "The Canadian Pacific Railway. Contract between the Government of the Dominion of Canada and the Canadian Pacific Railway Company; also the Consolidated Railway Act (1879,) and the Act of 1881 amending it." 8 vo. Ottawa, 1882.

LOCATION.

The general feature of the North-West Territory is a great undulating plain, divided into steppes, or plateaus. The first steppe extends from Winnipeg to Moose-Jaw Creek, 388 miles; here the ascent to the second plateau begins, and the country rises 275 feet in 7 miles. From this point to the crossing of the River Saskatchewan, a distance of about 224 miles, there are numerous difficulties. The pitches in the Coteaus are very rapid and irregular, especially so in the Missouri Coteau, where the country rises ridge upon ridge, like miniature mountains, and falls into deep and abrupt valleys. Had cuttings been possible there would have been less difficulty of location, and lighter works; but these are not practicable, as it is a matter of great importance to keep the grade in filling (or embankment,) to avoid blockade by snow; this added greatly to the difficulty of location. The dryness of season in winter pulverises the snow, and makes it like very fine sand. It drifts before the wind much more freely than in the eastern provinces, and packs so solid that a horse and sleigh can pass over it, leaving scarcely any impression. A drift of this very fine snow, 6 inches deep, during a "blizzard," will bring to a dead stop the most powerful engine. The snow has very little consistency, the wheels crush it on the rail, on which it forms a coating of ice, and effectually bars the way of the locomotive. A drift 3 feet deep in the eastern provinces can be charged and cleared but such a drift on the line here would have to be dug out.[3]

The limitations of curvature are to 4° curves (1433 rad), and of these only three have been used between Winnipeg and the crossing of the River Saskatchewan. Grades are limited to 40 feet to the mile (1 in 132); but it was found necessary to increase this limit to 50 feet to the mile (1 in 105.60) in ascending the Missouri Coteau. Grades are compensated for curvature, at the rate of 0.05 foot per 100 feet for each 1° of curvature[4]. No hindrances occurred in setting out the line, and the graders were never delayed an hour.

The locating parties were kept ahead of the graders all the season, and were an independent staff to those employed on construction. They had to explore an unknown country, and, in addition to exploration, had to align the permanent location, the constructive staff doing no locating, only putting in grade-pegs, and attending to monthly measurements. In the season of two hundred and thirty-nine working days, 840 miles were permanently located, being an average of 3.51 miles per day. Including trial locations, many camps made a daily progress exceeding 6 miles.

CAMPS OF SUPPLY.

The engineering staff consisted of five divisions, having charge of a length of 30 mile each. Each divisional engineer had three assistant engineers under him, to each of whom a length of 10 miles of construction was allotted. His camp consisted of a rod-man, axe-man, and cook. As his section was completed, he was shifted farther west, and so the staff was kept moving all the season. Supply-camps were 20 miles apart, and carts were kept on the road during continuance of work, distributing supplies. The contractors' supply-camps were 25 miles apart, and as stores were brought up by the teams they were freighted forward in trains of from thirty to forty teams. A "team" consists of a pair of horses and large four-wheeled wagon, and was used in preference to the Red River cart. These famous carts are two-wheeled vehicles constructed entirely of wood, the wheels not even being tired with iron. Long strings of these, drawn by cayuses (native ponies), used constantly to be met going east and west with supplies for the Hudson Bay forts and Indian reserves. The contractors had four trains on the road all the season.

There were three camps of supply, which usually covered 100 miles; the farthest off was 75 miles from the track, and this supplied the line for the remaining 25 miles. More than four thousand men, and seventeen hundred teams of horses and mules were employed by the contractors constantly during the season; and the company had a large force at the rear, finishing up the work. Two-thirds of the number of teams consisted of mules, it being found that they did as much work as the horses, stood hardships better, and their cost of keep was about two-thirds of that of a horse, as they could subsist better on the prairie grass than horses freshly imported from the province of Ontario. The Montana ponies are also very hardy, and stand an immense deal of work. Water was usually plentiful; but in some places during the dry season it was scarce, and had to be carted long distances. It was not always practicable to sink wells, as camps were moved so constantly, and the substrata did not permit of Abyssinian or other tube-wells being employed. As illustrative of the commissariat arrangements necessary, it may be mentioned that 75,000 bushels of oats were consumed monthly, and in one particular month as much as 95,000 bushels.

CONSTRUCTION.

The contract for the whole work, including grading, bridge-building and track laying, was let to Messrs. Langdon, Shepherd, & Co., under contract to complete and have ready for traffic in twelve months 500 miles of railway. This contract was rigidly enforced by the directorate, and they found in the contractors energetic and willing assistance. It may be contended that on the plains, with works so generally light, there should be no great difficulties in building a large mileage in one season. It is not easy without a large map and numerous drawings to explain the magnitude of the undertaking, and to convey a proper estimate of the difficulties to be overcome in the construction of this line. In the first place, the country into which the railway was entering was unexplored, and uninhabited; and arrangements were required to be made to send out surveyors for explorations, to be followed by engineers for construction; the workmen had all to be gathered from different parts of Canada and the United States, and forwarded; and there were the enormous commissariat organizations necessary for men and beasts. This was no mean task of itself. Added to this there had been a large immigration into Winnipeg in the spring, and the resources of the city were taxed to their utmost to afford accommodation to the incomers; all these people had to be moved out west in the spring, at the same time that preparations were being made for beginning the work. And as they settled and formed small towns and villages, the requisite station-buildings, side-tracks, etc., had to be put up. The materials for tracklaying had also to be hurried forward, as the track was a considerable distance behind the graders.

When the spring opened, the country was visited with very heavy floods, which affected the whole valley of the Red River for 250 miles south of Winnipeg. Such floods had not been known for more than a quarter of a century; not only did they destroy large portions of the railroads south and north of Winnipeg, but they flooded the whole country for miles along the valleys of the Red River and its principal tributary, the Assiniboine. The destruction to

[3] A large number of cuttings were also made in the rough country between the eastern line of the Missouri Coteau, and the Saskatchewan River; but all of these have, during the past season (1883,) been practically eliminated as far west as Swift Current, by the grading away of the higher ground on either side, or by raising the track; and all the remaining cuttings will be treated in the same way during the coming season (1884,) with, perhaps, one or two exceptions, where it will be impracticable. W. C. Van Horne, General Manager, C. P. R.

[4] Minutes of Proceedings Inst. C. E., vol. lxiii., p. 133.

the railroads was so great that the freight was blocked on the side tracks for hundreds of miles, and it was not until the month of May that the lines became clear. The wash-outs had to be repaired before any traffic westwards could begin, or supplies be brought from the south. The difficulties of this season's work were not therefore confined to construction on the plains; they embraced the permanent engineering staff for the repairs on the track, the constructive staff, and the freight-staff for forwarding passengers to their destinations, and supplies of all kinds to the working parties. All this had to be moved over a single track. Keeping these facts in mind, the progress of the undertaking this season is justly entitled to be ranked among the highest engineering successes of the day. The mode of construction of this and other lines on the American continent being different to that employed in Great Britain, and, so far as the authors are aware, never having been brought under the notice of the Institution, they venture to describe it somewhat in detail.

STATION WORK.

This consists of letting short portions of the line in lengths of 100 feet, called "stations," to gangs composed of from one to four laborers, who throw up the bank from side-ditches. It has the advantage of employing local labor, as settlers between times of cropping and harvesting are enabled to earn a little ready cash; and it gives employment to numerous half-breed settlers, whose mode of life prevents them from taking long engagements, and who are also unfit for other work. This class of work is also very much in vogue among the Swedes and Norwegians here, who make it their regular business; they are excellent workmen, neat, correct, and expeditious. The authors have never met any navvies who can approach them for power of endurance, and for neatness in the execution of their work. A Swede or Norwegian will cast in 25 cubic yards a day as an average day's work, and if pushed, or laboring in easy-going stuff, will put 50 cubic yards a day, and keep it up for several days. No plant is required, the embankments being cast up in all cases, a few planks and barrows are sometimes necessaay in very wet places.

SCRAPER WORK.

This is the regularly recognized mode of construction, and is the most effective. The side-ditches, or surface of the ground in cuttings, where the haul does not exceed 50 yards, is first ploughed, and the material is then hauled to the bank in an iron box scraper, which holds about ½ cubic yard. The outfit required is one plough-team and driver to five scrapers in ordinary soil; each scraper has a team, driver, and scraper-holder; every scraperful has to be hauled on to the dump, consequently it is well trodden down and consolidated, and shrinks very little. As this system can be adapted for embankments up to 10 feet in depth, and no expensive outfit is necessary, it is peculiarly well adapted for public work in a sparsely populated country. Here again the settler can obtain employment for his horses, either for the plough or for the scraper. An average day's work is 60 to 100 cubic yards, according to material. In the opinion of the authors this is much better than the system of wheeling in shallow dumps with barrows, or laying temporary rails and tipping from a wagon; for even in cases where a cutting has to be taken out, a long farmer's cart, having bottom and sides removable, can be substituted, and every layer thoroughly worked down by the horses. Where leads are too long for slush-scrapers or the dumps too high, wheel-scrapers are used. They are iron boxes, hung on an axle between two wheels, and are drawn by a horse in trams like an ordinary cart. They are easily tipped, and hold ½ cubic yard.

(TO BE CONTINUED.)

## Liverpool Engineering Society.

The ninth meeting of the session was held on Wednesday evening, Oct., 8th, at the Royal Institute, Colquitt-street; Mr, R. R. Bevis jun. in the chair, when a paper, enttled "Inland Navigation Works Abroad," was read by Mr. R. L. Tapscott. The author, in treating of his subject, dwelt on the accomplishment of the great canal works of recent years as a result of the improvements in the various mechanical appliances now snbstituted for hand labor and the benefits thence arising: instancing the successful maintenance of the Suez Canal as the forerunner of the many suggestions for inland navigation now brought forward. Admitting the difficulties of Panama Canal to be considerable, he held that they were yet of a similar nature to what have been overcome before; but, all taken together, presented an unparalleled series. Whatever the cost, the work had every appearance of proving a financial success. Passing on, the Amsterdam Canal was instanced as illustrating the surmounting of difficulties which the early part of this century dare not approach. Amongst the other works and schemes mentioned were the entrance to the Mediterranean by means of the Garonne River, the flooding of the Sahara, the draining of the Zuyder Zee, the improvement of the Neva, and the piercing of the isthmuses of Malacca, Florida and Corinth.

## Civilization in Central Africa.

"One railway," said Mr. Capper., as he looked in at the *Pall Mall Gazette* office the other day on his way to the House of Commons, where he was expected to give evidence on a Welsh railway bill and Thames communications: "one railway is worth ten bishops in Africa" That is what Sir Lyon Playfair once said, and I entirely agree with him. I think that if all the missionary societies were to devote a year's income to the construction of a Central African line of railway from the highest navigable point of the Niger to the Congo, they would do more for the Christianization and civilization of the Dark Continent than all the efforts of the missionaries for the next fifty years. It is a great delusion to imagine that the African native is not quite as goood as many Europeans, and a good deal better than some Europeans. I have travelled on foot 4,000 miles down the African coast, going in at the Niger and coming out at Loanda, and my experience is that in manliness and shrewdness, and intelligence and honesty, and in the essentials of government, the black man is quite as good as the white. Boil down your idea of civilization as much as you please, and unless you make it consist of the mere use of pocket handkerchiefs, you will find that these so called savages are civilized as any of ourselves, They are traders, and keen traders, too. They have their own religion, their own laws, and their own patriarchal methods of life. All the best of them are Mahommedans. They administer justice in their own way, and show more hospitality to the traveller than the ordinary Englishman or foreigner.—*Pall Mall Gazette.*

THE following table shows the increase in the consumption of steel for rails in France, with the decrease in the use of iron.

| | Iron rails. | Steel rails. | Total. |
|---|---|---|---|
| | Tons. | Tons. | Tons. |
| 1873 | 135,000 | 85,000 | 220,000 |
| 1874 | 154,000 | 123,000 | 227,000 |
| 1875 | 104,000 | 139.000 | 243,000 |
| 1876 | 57,000 | 161,000 | 218,000 |
| 1877 | 53,000 | 171,000 | 224.000 |
| 1878 | 50,000 | 211,000 | 261,000 |
| 1879 | 39,000 | 231,000 | 270,000 |
| 1880 | 38,000 | 262.000 | 300,000 |
| 1881 | 28,000 | 290,000 | 318,000 |
| 1882 | 27,000 | 350,000 | 377,000 |

## Creeping of Rails.

The Engineers' Club of St. Louis held the first meeting of the season on Oct. 22. at Washington University, President Woodward in the chair. Mr. J. D. Sanders was elected a member of the club The paper for the evening was read by Mr. J. B. Johnson, his subject being the "Creeping of Rails on the St. Louis Bridge." Mr. Johnson said that on the St. Louis bridge proper the rails had been known to creep 260 feet in one year, and on the bridge approach 400 feet. This creeping varied with the amount of traffic or with the weight carried over the rails. On the St. Louis bridge the rails crept in the direction with the traffic. These rails were supported from their base. The reason given by Mr. Johnson for the creeping was that the rail, being held fast on the extended ties, is caused to measure its length across the bridge on its extended flange whenever a heavy weight passing over it causes a wave in the rail. This wave has been known to raise the rail between the two trucks of a car three-eighths of an inch, and the creeping has been measured and at times has amounted to one-half to three-quarters of an inch. If the rail is supported at a place above its neutral axis, the creeping will be opposite in direction to the traffic. This Mr. Johnson demonstrated satisfactorily with a circular track of hickory. There must be some intermediate point, Mr. Johnson argued, at which the rail would have no desire to creep. The hour being late, discussion of the subject was postponed to the next meeting of the club.

THE WEIGHT OF HARD-WOODS.—The following is given as the weight of hard-woods per foot, board measure. Some allowance must be made in the weight of fresh cut, as the same wood when green differs somewhat in weight in different localities:—

| Name of wood. | Green. lbs. to 1 foot | Dry |
|---|---|---|
| Ash | 4½ | 3½ |
| Apple | 5 | 4 |
| Beech | 5 | 4½ |
| Birch | 4½ | 3½ |
| Basswood | 3½ | 2½ |
| Chestnut | 4 | 3 |
| Cherry | 4½ | 3 1-5 |
| Cypress | 4 | 3 |
| Cedar | 4 | 3 |
| Elm | 4 | 3 |
| Hickory | 5 | 4½ |
| Holly | 5½ | 4½ |
| Lignumvitæ | 9 | 8½ |
| Maple | 5 | 4½ |
| Mahogany | 5½ | 4½ |
| Oak | 5 | 4½ |
| Poplar | 3½ | 2½ |
| Rosewood | 8 | 6½ |
| Walnut | 4½ | 3 1-5 |

*Miss. Valley Lumberm an*

THE earnings of the railroad from Samarang to Vorstenlanden in the island of Java must have been very comforting to the shareholders. The following figures show the length, cost of road and earnings:

| | | |
|---|---|---|
| Length (miles) | | 125 |
| Cost of construction | | $7,746,000 00 |
| Cost of construction per mile | | 62,000 00 |
| Earnings | Passenger | 206,000 00 |
| | Freight, etc | 1,041,000 00 |
| | Total | 1,247,000 00 |
| Expenses | | 405,000 00 |
| Per cent. of earnings | | 32.5 |
| Earnings per mile | | $10,000 00 |
| Expenses per mile | | 3,250 00 |
| Earnings per train mile | | 4 80 |
| Expenses per train mile | | 1 56 |

The profits are $3.24 per train mile and exceed the earnings of roads in this country greatly. Those of the Pennsylvania Railroad last year were 59 cents, while the New York Central had 57½ cents, the Erie 48 cents, the New York, New Haven & Hartford 67, the Lake Shore & Michigan Southern 71, the Chicago & Alton 86, and the Chicago, Burlington & Quincy $1.12 earnings per train mile.

A LONG article appears in the *Annales Industrielles* proposing another Alpine tunnel as necessary to meet the growing traffic between France and Italy for which the Mont Cenis is not sufficient. The tunnel would be part of a line connecting Martigny and Aoste, the tunnel being 9.48 km. long, between the Glacier de Laneuva and the Glacier de Rochefort and the line passing between Mont Blanc and the Great St. Bernard.

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AND

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THE American Institute Fair, which closed its doors this week, has been rather waning in interest of late years, as far as engineers are concerned.

In the back part of the building were to be found a number of exhibits of engines, pumps, crushers, machine tools, etc., but little of a sufficiently startling novelty to warrant a description. In an exhibition of this nature the effort is always to astonish and please the uninitiated rather than to instruct those in search of information, and that rare article know as "Something new under the Sun." In consequence the exhibits are grouped with the object of producing an effective whole, instead of showing the working details; and the attendants, bored by the questions of the gaping multitude, who cannot distinguish between a slide valve and a fly wheel, confine their answers to glittering generalities, which are exasperating in the extreme to one who is endeavoring to get at some technical detail which comprehends the entire novelty, and to him the entire interest of the machine under examination.

Among the more creditable exhibits were the Delamater hot air engines, the Gaskill direct acting steam pumps, and Gould & Eberhardt's display of machine tools. The Farrell crusher, on the Blake principle, was there masticating its usual diet of broken stone, and a number of little gas engines, similar to that which we recently illustrated, were pumping over and over again the several gallons of water allotted to them.

WE notice, in the *Philadelphia Press*, that the Water Committee of the Councils of that good old city have been making their annual tour of inspection along the shores of the Fairmount Pool.

The *Press* reporter graphically sketches the astonishment and indignation of the city fathers at the quantity and quality of the filth that is being daily dumped into the main source of Philadelphia's water supply,—their "horrified silence" and "unheeded protests," their indignation meeting held on a dump at Manyunk, are all well depicted.

From the general tone of the comments made a casual reader would suppose that these reputed guardians of a great city's welfare had never before heard of the many violations of sanitary law common on the banks of the Schuylkill. All that we can say is that they are either very forgetful men or they have been very inattentive to the annual philippics on this subject hurled at them by the water department.

The facts have been known for years, and much paper and ink and breath have apparently been wasted in setting the facts before these very councilmen and their predecessors. Each year for a decade past, the committee has made its tour of inspection, ending always as did this one, in a dinner at the City's expense at Strawberry Mansion. A few men protest against the wrong in councils, and the majority vote against any measures tending to discommode their wealthy constituents, the manufacturers, and—the thing is forgotten until the next junketing expedition.

This has been the rule in the past, the committee is always "horrified," and are always going tobring an injunction against the perpetrators of this more than nuisance. But will the committee of 1884 get beyond the stage at which all preceeding committees halted?

In the meantime the people of a large city are being poisoned, in homeopathic doses it is true, but by a process that increases in danger with each year, by a natural law of accumulation and business growth.

Other towns besides Philadelphia have been subjected to a similar pollution of the domestic supply, and have taken energetic measures to prevent it. And why does not our neighbor, with greater interests at stake and more means at her command, follow their example? As we have already pointed out their is *no* excuse for emptying a sewer into the forebay of a pumping station, and if they are in earnest about it, they can also prevent mill owners from using the source of water supply for a dumping ground for their waste products of acids, dye-stuff and wool-washing. A little less driving about in city carriages and eating of city dinners, and a little more decided action in the Council chamber would be, perhaps, less agreeable to the committee, but certainly more beneficial to a long suffering community.

As an addenda to our remarks above, we give the opinions of Chief Engineer Ludlow upon the prevention of pollution in the Fairmount Pool, with other notes relating to the same subject.

Col. Ludlow claims that the city itself is one of the greatest sinners in emptying house drainage into this pool, which might well be disposed of by sewers. The intercepting sewer now under construction along the river bank will eventually take care of this.

The liquid drainage of dye-stuffs, etc., can also, in great part be handled by the same sewer, but the solid matter, such as wool waste, pulp from the paper mills and animal, vegeable and mineral refuse of all kinds must be otherwise cared for. In the center of the city, all such matter must be carted away and the very sensible question is asked why the same thing cannot be done at Manyunk.

Prof. Leeds, of the Stevens Institute, quotes the Passaic as a stream at one time in a worse condition than the Schuylkill, and by matter of much the same character. The Passaic is now rendered comparatively pure by depositing the sewage from the factories in tanks of a peculiar construction, and carting away all solids. The dye-stuffs, etc., are poured into a series of settling tanks, considerable matter valuable to the mill owners is recovered and the purely liquid portion cheaply filtered through sand and gravel before being allowed to finally escape. The manufacturers themselves are so pleased with the process that they would not willingly return to the older methods of disposal.

In regard to the usual resolution that the Chief Engineer and City Solicitor be empowered to take the necessary legal steps against the manufacturers, a resolution which to date has amounted to *nil*, it is stated that a legal contest is possible, as these men claim the property to the orginal low-water mark, which is now far beyond the present shore-line. But as against this it is urged that these owners have not exercised their right for more than twenty years and, moreover, have no right to use private property for the public injury.

### The "Rocket of 1830."

The London *Engineer* presents its readers with a facsimile of a free-hand drawing by the celebrated James Nasmyth showing "a sketch of the Rocket I made at Liverpool on the 12th of September 1830, the day before the opening of the Liverpool and Manchester Railway, while it remained stationary after some experimental trips, in which George Stephenson acted as engine-driver and his son Robert as stoker."

In the London *Mechanics Magazine, Museum, Register, Journal and Gazette*, of Saturday October 16, 1830, is an engraving of "Messrs. Stephenson's locomotive-engine the Northumbrian," which is undoubtedly the engine depicted in the *Engineer* and reproduced in the *Railroad Gazette* of October 17. Mr. Nasmyth's sketch is a very correct one of this engine, the braces to the smoke-stack and the guards over the drivers alone being missing in the original engraving of 1830 mentioned.

The *Magazine* referred to speaks of this engine as "one of the latest made and one of the best of Mr. Stephenson's engines, and it is distinguished from his other engines by having its boiler and chimney of copper instead of iron."

The "Northumbrian" was one of the eight locomotives used at the opening of the Liverpool and Manchester Railway, on September 15, 1830. These engines were, the "Northumbrian," driven by Geo. Stephenson, the

"Phœnix" by Robert Stephenson, the "North Star" by Robert Stephenson (brother of George,) the "Rocket," by Joseph Locke, the "Dart" by Thos. L. Gooch, the "Comet" by William Allcard, the "Arrow," by Fredrick Swanwick, and the "Meteor" by Anthony Harding; all built by the Messrs. Stephenson & Co., at Newcastle.

According to the *Mechanics Magazine*, the "Northumbrian took the lead of the procession, drawing a splendid carriage appropriated to the reception of the Duke of Wellington Sir Robert Peel and about thirty other distinguished individuals."

It was this same "Northumbrian," driven by Mr. Geo. Stephenson himself, that after the sad accident that eventually cost Mr. Huskisson, the Home Secretary, his life, carried Mr. H. fifteen miles in twenty-five minutes, an event then quoted as "the most marvelous achievement yet."

From this data we believe that the solution of the problem now puzzling our contemporaries, is, that Mr. Nasmyth after making a sketch of what was undoubtedly the most conspicuous among the eight engines present, simply made a mistake in calling his drawing "the Rocket," which it in no wise resembled.

### The Transportation by Running Water of Mud, Sand and Gravel.

M. L. L. Vauthier, Engineer of Bridges and Roads, lately read a paper upon this subject before the French Association for the Advancement of Science at the meeting at Blois. We make the following extract as published in *Le Génie Civil*:—

Dubuat, in the last century, elaborated analytically the problem setting forth the principles, admitted by all hydraulicians, that the resistance of water to the movement of a body displaced in it is proportional to the square of the velocity and the greatest transverse section of the body normal to the direction of the movement.

The formulæ derived, both for velocity and the distance travelled (the velocity depending naturally upon the density of the body under consideration,) show that the conditions of movement of bodies of like form vary as the square root of homologous dimensions. They also point out the remarkable fact, of great importance in the treatment of this subject, that when the density varies between 2 and 2.5 the velocity of fall tends very rapidly towards a *limiting velocity*, which is never reached, but from which the actual velocity differs to an extremely slight degree at the end of very short periods. This is especially verified in bodies of small volume but is equally true for large masses.

The author has applied his figures to bodies of a spherical form having a density of 2. The results would closely approximate however for bodies of any other form.

Some of these results, relating to spherical bodies, are given in the following table, where $V_1$ is the limiting velocity, and $T_1$ the time of fall in which the effective velocity differs less than a thousandth from the limiting velocity:—

| Diameter of body. | Values corresponding to $V_1$ | $T_1$ |
|---|---|---|
| 0·0001 | 0·0516 | 0″039 |
| 0·001 | 0·1623 | 0″124 |
| 0·01 | 0·5164 | 0″392 |
| 0·1 | 1·6230 | 1″241 |
| 1 metre | 5·1640 | 3″924 |

For a density of 2.5 instead of 2. the figures in the last two columns will slightly differ but they will preserve absolutely the same relation or character.

It is noticed that for bodies of slight volume up to a diameter of one *centimeter*, the period of variable velocity is so short that the movement can hardly be considered; practically it is uniform, and that, even for bodies of very considerable volume, this period is relatively very limited.

As to the limiting velocity itself, extremely feeble for tenuous bodies, it still remains for larger bodies much inferior to that which it would possess in a vaccum at the end of some seconds of fall. A spherical body 0·10 in diameter would have acquired at the end of 1.24 seconds fall a velocity of 12 40, while its velocity in water at that moment does not surpass 1·62, and after that does not sensibly increase. For a sphere 1 *metre* in diameter, the velocity, at the end of 3.92 seconds, would be 39·20, and would continue to increase; in water this velocity becomes almost uniform and never exceeds 5·164 by more than a thousandth.

The deductions from these results are very important in explaining the action of running waters upon the bed and sides of the channel.

At the moment that a body of the density of stone is dropped into the water it is there displaced with the velocity $V_1$; the body will be held in equilibrium in an ascending current moving with this velocity, if it is vertical; or, if it is inclined, with a vertical component equal to $V_1$. If this vertical component exceeds $V_1$, the body will be carried upwards, but without ceasing, however, its retrograde motion towards the bottom of $V_1$ in each second. This is a mode of impulse and special transport whose conditions are easily understood.

These simple considerations suffice to explain all the phenomena taking place in running streams, relating to the transportation of material, without having occasion, as is done by some modern hydraulicians, to endow the water itself with a power of special suspension more or less mysterious.

In natural watercourses, following the greater or less inequalities of the bottom, currents are produced in the neighborhood of the sides of the confining channel more or less energetic. With vertical ascending components of some *centimetres* per second, the currents will take up the lighter mud; when these components reach a velocity of some *decimetres* sand more or less bulky will be lifted; gravel two *centimetres* in diameter, moves with a component of 0·5 to 0·75; and when the velocity reaches one metre and exceeds this, it will act upon pebble-stones; at 2 metres blocks of stone are transported, and with a velocity of 5 metres these blocks may reach dimensions of one metre cube.

Currents of this last intensity are rare; but they are produced by the sudden increase of flow in water courses of large volume, as, for example, by the breaching of a dyke or dam artificially impounding water.

M. Vauthier concluded his remarks as follows:

"In conclusion, it would seem that the following would result from that which precedes:—

"That water does not possess any special property by virtue of which it can hold in suspension matter of a density superior to its own.

"That such matter tends always towards the bottom with an almost uniform velocity, which depends upon the density of the body and which is inversely as the square root of the transverse dimensions of the body.

"That, with regard to the before mentioned velocities, for material of a density similar to that which forms the sides of the channel, the effects of displacement and of transport observed in streams and rivers are very simply explained by the fact of permanent or accidental currents which act in these streams.

"That, to the proper understanding of these effects, it is absolutely necessary to take into account the degree of tenuity of the impelled matter, and that which is true for matter extremely divided, as in the Garonne at Bordeaux and in water courses great or small during a flood, may be false in the extreme for matter more bulky.

ENGINEERING NEWS Three months for One Dollar.

### PERSONAL.

HENRY T. ANTHONY, best known as a member of the firm of E. & H. T. Anthony & Co., dealers in photographic materials, died in New York on October 11th, aged 71 years. Mr. Anthony graduated from Columbia College in 1832, studied civil engineering and was an assistant on the Erie R. R. and on the Hudson River R. R., and at one time was employed on the Croton Aqueduct. He was the originator of many improvements in practical photography, and had charge of the manufacturing department of his firm.

### The St. John Railroad Bridge.

According to the *St. John* (N. B.) *Telegraph*, of Oct. 10, work is progressing rapidly on the new cantilever bridge at that point, and it is expected that it will be opened to traffic by January 1, 1885.

The total length of the bridge between the anchorage piers is 816 ft. with a central span of 477 ft. The shore arm is 190 ft. and it is first constructed and is held down by 16 steel anchorage rods. Just the reverse of the Niagara Bridge, the bottom chord is horizontal, the top chord being inclined. The depth of span over pier is 80 ft.

Work on the eastern end will commence shortly, preparations are now being made for the erection of the false works for the shore arm. Mr. F. E. Came is Asst. Eng. in charge and Mr. H. Hasler is Foreman in charge of erection; both these men are representatives of the Dominion Bridge Co.

### Engineers Club of Philadelphia.

Regular Meeting of Oct 18th., President Ludlow in the chair. twenty-five members present.

Mr Henry Roney exhibited and explained a Portable Storage Battery for Mining and Exploring purposes. It was a modification of the Plante battery drived by Dr. E. T. Starr, of Philadelphia.

Mr. Wm. L. Simpson exhibited and described the Thompson Steam Indicator. Cards can be taken with the machine from pressures as high as 500 lbs. to the square inch.

Mr. J. J. deKinder described the repairs to the Belmont submerged main, Philadelphia Water Works. The special novel feature was a floating coffer-dam, balanced by water.

W. Bugbee Smith introduced the subject of Fire Protection of Mills, advocating heavy wooden posts and girders, solid plank floors and roof, and automatic sprinkler pipes.

### Large Cranes.

There is now being erected on the dock of Hambourg, a gigantic crane for use in handling cannon of 125 tons weight each, as built by the Krupp establishment; the full capacity of the crane is 330.000 lbs.

The next largest machine of this type is that at the port of Anvers with a lifting power of 120 tons. After that are those at Woolwich of 100 tons; at Amsterdam, of 80 tons; at Brinerhaven, of 60 tons, and at Hambourg, of 40 tons.—*Le Génie Civil.*

THE new railroad enterprise in the vicinity of St. Joseph, Mo., are the St. Joseph and Rio Grande Railway, the La Crosse, Iowa and Southwestern, and Southeastern, Quincy, Missouri and Pacific, and St. Joseph, Joplin and Gulf Roads. Some of these are entirely new roads, which have good promise of construction. Others are roads which will before another year be extended to St. Joseph.

## CORRESPONDENCE.

Special Correspondence Engineering News.

BAY CITY, MICH. Oct. 27, 1884.

EDITOR ENGINEERING NEWS:—Can you tell what an "English load" is? Answer in your next issue.

F.

[Haswell gives, under the head of "Builders measures," One English load timber, rough = 40 cubic feet, hewn, 50 cubic feet. This is the only "English load" we can find. Perhaps some of our readers can further explain.—ED. ENG. NEWS.]

### New York and Pennsylvania Boundary Survey.

SYRACUSE, Oct. 27, 1884.

EDITOR ENGINEERING NEWS:

Referring to the copied article in your current issue upon my work upon this Boundary, it goes without saying that the interview was by no means a *verbatim* report, and in the paragraph relating to visits of commissioners, I am made to do them an injustice. The remark applied solely to the New York branch of the commission, and was taken up, I suppose, because Gen. Leavenworth happened to be a resident of this city. Col. C. M. Gere, of Montrose, one of the Pennsylvania commissioners, who was originally designated as surveyor on the part of Penn. and who had been consulting engineer from the beginning, has spent a great deal of his time upon the line. And we have had several visits from Col. James Worrall, of Harrisburg, Chairman of the Joint Commission.

Very truly yours,
H. W. CLARKE.

### A Bad Case.

We have been under the impression that a more terrifying analysis of drinking water could be turned out from the Stevens Institute than from any other known source, except perhaps the Massachusetts Institute of Technology. But both of these excellent institutions will tear their hair in frenzy at being outdone by Dr. Klein, of London, who sent to his friend Dr. Browne, a native of Dumfries, Scotland, the following appalling analysis of the water supplied to that ancient borough.

"The water you sent me contains:—

1. Amorphous matter, in the shape of irregular granules.
2. Large masses of zoogiea of micrococci.
3. Few bacilli and spores.
4. Few bacterium termo.
5. Spores of hyphomycetes.
6. Saccharomyces mycroderma.
7. Zoospores of saprolegnia."

For the benefit of those who are without medical knowledge, says Dr. Browne, "I may briefly explain that these long names indicate that your water is of the worst possible description. It would be difficult indeed to conceive of any water which human beings could be induced to drink of a more dangerous and polluted character than one charged with the constituents enumerated by Dr. Klein. The amorphous matter in the shape of irregular granules to which Dr. Klein refers is made up of particles of sand and clay. The zooglea masses of micrococci consist of gelatinous lumps or colonies of fungi of that genus, species of which are most frequently found in connection with infective processes, and which are believed, under certain conditions, to play an active part in the causation of erysipelas, diptheria, scarlatina, measles, blood poisoning, surgical fever, and several other diseases. The bacilli, which are the best known of all microparasites, belong to that group of protophytes, or minute vegetable organisms, that is held directly responsible for splenic fever, malaria, and tubercular disease, including consumption, and that has been reinforced lately by the discovery of the dread cholera bacillus of Koch. The bacterium termo is the essential cause and invariable concomitant of putrefaction and decomposition. The hypomycetes are the mould fungi which are so constantly found on the surfaces of decaying organic bodies, whether animal or vegetable. The saccharomyces mycroderma is one of the yeasts which are concerned in fermentative changes. The zoospores of saprolegnia are the seeds and filaments of mosses. Your townspeople, now thoroughly awakened to the risks they run while their water supply continues what it is, will, no doubt, obtain the best advice as to the steps to be taken to place them in a position of safety. It seems to me exceedingly doubtful whether a water of the character revealed by Dr. Klein's examination can by any process of filtration be brought into a pure and potable condition. Until another and less equivocal source of supply than Lochrutton has been resorted to, or until the Lochrutton water has been cleansed and purified in a manner very different from any that has been yet adopted, the inhabitants of Dumfries would do wisely to swallow no drop of it that has not been well boiled."

### A Novel Method of Draining.

Recent experiments of Colonel John P. Fort, in southwest Georgia, in pond draining promises a revolution in the malarial sections of the South, which embrace the richest part of the country, and cover millions of acres. The great drawback of Florida, Louisiana, the rice sections of South Carolina and Georgia has been the fact that white men could not live there on account of brackish drinking-water, and malaria, inseparable from floods and swamps. Several years since, Captain Fort, who owns much property of this description, conceived the idea of sinking artesian wells, holding that when a certain stratum was reached pure water could be obtained in abundance. His efforts were crowned with such success that every town in southern Georgia is sinking artesian wells. The water is perfectly clear, sweet, and pure as the best to be found in the highlands. This success led Colonel Fort to try the experiment of draining stagnant ponds by running them off through subterranean passages that are known to exist at a distance of from seventy to a hundred feet below the surface. Colonel Fort's experiment was made on his hickory level plantation, in Dougherty County, and the pond upon which he experimented is situated about two hundred yards from his pioneer artesian well. The pond covered an area of about two acres, with a depth of ten feet in the center. To drain it thoroughly an outlet must be made in the deepest part. To accomplish this Colonel Fort bound four substantial pieces of timber together, floated them over the center of the pond, and upon this foundation built his raft or pen, which sunk as it was added to. When the raft had been built, the foundation resting on the bottom of the pond, the platform was across the top, and on this platform a derrick was set up. To this derrick boring apparatus was attached. At first a pile-driver was used, but when the pipe had been driven down through the bottom of the pond to a depth of thirty feet it rested on solid rock, and then the work of drilling and boring was begun. At a depth of fifty feet below the bottom of the pond the drill struck an opening, and at once the water commenced to sink with a roar through the big pipe, the top of which was only a few inches under water. The drill-pipe was drawn out, and the pond commenced to empty itself as fast as the orifice that the drill had made through the rocks would permit the water to flow. When the water in the pond was level with the top of the pipe a reamer was attached to the drill-pipe, and sent down to open the way for the big pipe to be sunk deeper. In this way the pipe was sunk until a joint of two sections was almost level with the bottom of the pond, and there it was unjointed. Colonel Fort will have a square pit dug around the pipe, and the pipe will then be driven down to a level with the bottom of this pit. The top of the pipe will be covered with wire to keep trash out, and the pit will be filled with rocks, and thus the drain will be kept open. This strange scene of emptying the pond into subterranean channels has been witnessed by hundreds of people, who see in it the reclamation of the millions of acres of swamp lands in the South. Thus, within two hundred feet of each other, were two pipes, that of the artesian well throwing up the purest of drinking-water, and that in the middle of the pond sucking stagnant water into the bowels of the earth, and carrying it away. The experiment cost only $75, while there were gained from it over two thonsand tons of compost soil.—*Boston Transcript.*

### LITERATURE.

FROM THE INSTITUTION OF CIVIL ENGINEERS.

*Gas Engines*, by AMIE WITY. *Translated and Abstracted*, by EDWARD HOPKINSON, D. Sc.

*Area of Sluice Opening necessary for the Supply Sluice of a Tidal Canal*, by J. H. ARJOHN, M. A. M. INST. C. E.

*Passage of Upland Water through a Tidal Estuary*, by R. W. P. BIRCH, M. INST. C. E.

*A Dioptric System of Uniform Distribution of Light*, by A. P. TROTTER, B. A. ASSOC. M. INST. C. E.

*Old Water Supply of Seville*, by GEO. HIGGIN, M. INST. C. E.

*New Harbor of Trieste*, by FRED BOMCHES.

*Distilling Apparatus at Iquique*, by C. M. JOHNSON, B N. ASSOC. M. INST. C. E.

*Galvanic action between Wrought-iron, Cast Metals, and various steels during long exposure in Sea-Water*, by THOS. ANDREWS, F. R. S. E. ASSOC. M. INST. C. E.

*Abstracts of Papers in Foreign Transactions and Periodicals.*

*Wood Pavement in the Metropolis*, by GEO. H. STAYTON, ASSOC. M. INST. C. E.

*The Antiseptic Treatment of Timber*, by S. B. BOULTON, ASSOC. INST. C. E.

*Sewering of Towns on the Separate System. Size and Inclination of Sewers*, by A. E. WHITE, ASSOC. M. INST. C. E.

*Lighthouse Apparatus for Dipping Lights*, by ALAN BRABNER, JUN. B. SC. ASSOC. M. INST. C. E.

*Coaling at the Nine Elms Gas Works*, by ROBT. MORTON, M. INST. C. E.

*Light Draught Launch*, by E. W. COWAN, and JAS. FAWCUS, STUDS. INST. C. E.

### New Zealand Government Railways.

The general manager of the New Zealand Government Railways has just presented his report upon the working and progress of the lines in 1883. He states that 49 miles of rails have been laid against 36 miles in the previous year. Only 293 miles, out of 893 miles are now laid with rails below the standards, taken at 53 lb. for the main line and 40 lb. for the branches. The consumption of sleepers has risen since 1879–80 from 50,000 to 100,000. The bridging is heavy and expensive to maintain, being chiefly of timber. In the Christchurch district there are 8 miles 76 chains of bridging; in the Dunedin district there are 3 miles 69 chains; in the Invercargill district there are 1 mile 43 chains—a total of 14 miles 27 chains. The cost of maintaining this will increase annually. During the year 60 miles of live fences have been planted, and 20 miles of ground have been prepared; 66 acres of plantations of trees have been made, and 50 acres of ground have been prepared. Extensive additions have been made to station accomodation, and appliances at Invercargill, Addington, Parkfield, Chaneys, Valette, Mabeno, Palmerston, Burkes, Burnside, Henley, Mataara, Bluff, Winton, Gore, Waipnhi, Stirling, Milburn, Waikouaiti, and Edendale. Numerous cranes, weighbridges, and improvements to water services have been added. The expenditure by the maintenance department has been: For maintenance, 159,477*l.*; public works department, 31,104*l.*; general public, 6914*l.*; total, 197,495*l.* Six new private sidings have been granted and 99 leased. The revenue from leases now amounts to 5352*l.* per annum. In the locomotive department five new tender engines have been added to the stock. The stock of wagons has been increased by 402, the carriage stock by 13, and the tarpaulins by 458. The expenditure on wagon renewals has been heavy. Brown coal has been chiefly used, giving good economical results. The workshop accommodation has been largely improved, and is now, with some exceptions, fairly equal to the present requirements. The engine shed accommodation is insufficient for the stock.

THE LENGTH OF FRENCH RAILS.—It is stated that the first railway line in France, viz., from St. Etienne to Andrezieux, had rails only 3 feet 11 inches long, and weighing 45 pounds. This was in 1828; but in 1832, on the line from St. Etienne to Lyons, the rail had increased in length to about 14 feet 8 inches, and to 132 pounds weight. Various increases continued thus to be made in France until the length reached 19 feet 6 inches. The great objection urged against the increase of length was that the iron rail exfoliated and was damaged at any point, instead of only at the ends. The case is different, however, with steel rails these being now turned out in Belgium and France some 85 feet in length. Considering the dilation due to changes of temperature, the maximum length of a French rail will probably be fixed at about 49 feet 3 inches.

## The Erection of the Waldlitobel Bridge on the Line of the Arlberg Railway.

The Waldlitobel Bridge crosses the valley of the Klosterle about 1½ miles from the Arlberg Tunnel. At this point the railway passes over a ravine about 164 ft. deep with sides rocky and very steep. The span of the main arch is

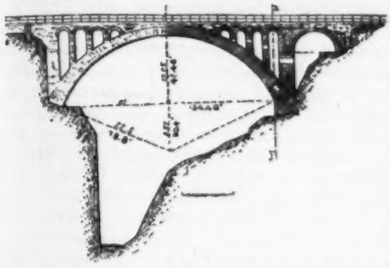

FIG. 1—THE WALDLITOBEL VIADUCT—GENERAL VIEW.

134.48 ft., with a second arch of 26.24 ft., as shown on FIG. 1.

To erect the main arch a scaffolding was built which included five trusses tied together longitudinally and transversely by diagonal bracing. The trusses were spaced 4.56 ft. apart, the width of the arch being 15 ft. At the bottom these trusses rested upon twin posts tied together by diagonals and iron clamps. Across the deeper portion of the ravine where posts were impossible, a truss was thrown as shown in Fig. 3.

Above the lower stage of the scaffolding a bridge was built 16.4 ft. high and including 9 bents about 16.4 ft. apart. Upon these bents were placed the sand boxes to be used in striking the bridge centers, and which sustained the centers proper. The lower part of the centers was 6.23 ft. above the springing line of the arch.

On the Insspruck side the rock formed a natural abutment while on the side towards Bludenz the abutment was built up of masonry.

The arches of the centers rest upon beams about 12 × 12 in., which are themselves carried by the sand boxes before mentioned.

The rise of the center is 37 ft., and the arch itself is built up of 8 curved segments united by bolts. These segments are jogged in saw-tooth form, as shown, and at their joints rest upon bolsters supported by braces.

With the exception of the vertical posts in the trestles, which are round and 12 in. in diameter, all the timber used in the scaffolding was squared. The transverse members are 12 in. square; the diagonals in tension are 6 by 8 in., and all the remaining timber is from 10 to 12 in. square. About 76,300 ft. B. M. of timber and 4 tons of iron were consumed in the construction of this staging. The cost of the center was 8 florins 9 kreutzers per square meter of longitudinal surface" and as the total surface was 1,130 square meters the total expenditure was 10,000 florins ($4,000.00.)

The bridge is for a single track, and at the cornice line has a width of 19.68 ft. (6 m.) and at the level of the rails it is 14.76 ft. wide. The main arch has a versed-sine of 43.4 ft., and is built of stone voussoirs roughly cut. The mortar used was made of one part cement and two parts of well washed quartz sand. The arch at the key is 5.57 ft. deep and at the abutments 10.17 ft.

The building of the arch itself was an interesting feature of the work, and we outline the method employed. The work was commenced at four points simultaneously, that is to say: at the two abutments and at two points equally distant from the crown as represented in Fig. 2. To accomplish this, two temporary abutments were constructed consisting each of a timber frame work made of 12 beams placed side by side. These abutments transmitted the weight of the masonry to the rocky sides of the ravine by means of two sets of struts each made of four timbers 10 in. by 12 in. and tied together as shown in Fig. 2.

This strutting in no way interfered with the building of the arch. The arch was thus keyed in three places. The closing at the crown presented no particular difficulty, but at the other two points great care was required, as it was necessary to first remove the artificial wooden abutments. The centers were struck six weeks after the completion of the masonry.

This original method of arch construction described was intended to prevent the deformation of the arch and has the advantage of more regularity in the drying of the mortar used, and in a marked degree, shortening the time of construction by permitting simultaneous work at a number of points.

Above the extrados of the main arch on each side of the key are four spandril arches each 6.56 ft. span; the piers of these spandril arches are also provided with arched openings. The upper floor is covered with a bed of beton about 3 in. thick, over this a bed of cement and an impermeable covering of special composition. When this coating was completely dry another bed of 2 in. of cement was put in place and finally a layer of sand 4 in. thick.

*Annales des Travaux Publics.*

## The Forth Bridge.*

BY B. BAKER.

(Continued from page 143.)

As it is impossible to produce the working drawings of the bridge on the present occasion, a short tabular statement of some of the leading features may be desirable.

| | tons. |
|---|---|
| Steel in main cantilevers | 40,000 |
| " center girders | 1,600 |
| " viaduct approach | 2,800 |

Cantilevers, 680 ft. projection; 343 ft. and 40 ft. deep.

Bottom member of cantilever, a pair of tapering tubes:

| | |
|---|---|
| Distance apart centers at piers | 120 ft. |
| " " " ends | 31.5 " |

Tube at piers, 12 ft. in diameter, 1¼ in. thick, 830 square in. area.

Tube at ends, 5 ft. in diameter, ¾ in. thick, 120 square in. in area

Top timbers of cantilever, a pair of tapering box lattice girders:

| | |
|---|---|
| Distance apart centers at piers | 33 ft. |
| " " " ends | 22.25 ft. |
| Girders at piers, 12 ft. by 10 ft. | 506 sq. in. net area. |
| Girders at end, 5 ft. by 3 ft. | 60 sq. in. net area. |

Columns over piers, 12 ft. diameter, 368 to 468 sq. in. area.

Diagonal struts (tubes), 8 ft. to 3 ft. diameter, 198 to 73 sq. in. area, and 337 ft. to 74 ft. long.

Diagonal ties (box lattice), 8 ft. to 3 ft. deep, 163 to 67 sq. in. net area, and 327 ft. to 82 ft. long.

Horizontal wind bracing (box lattice), 11 ft. to 3.5 ft. deep, 88 to 20 sq. in. area, 142 ft. to 40 ft. long.

Vertical wind bracing (box lattice), 4.75 ft. to 2.5 ft. deep, 84 to 28 sq. in. area, 160 ft. to 60 ft. long.

Central girder, 350 ft. span, 51 ft. and 41 ft. deep; bottom members, 32 ft. apart centers, 142 sq. in. net area; top members, 22.25 ft. and 19 ft. centers, 139 sp. in. gross area.

Internal viaduct, lattice girders with spans of 39 ft. to 145 ft.

Floor, buckle plates and trough girders.

Wind fence, close lattice work, 4 ft. 6 in. high.

Viaduct approach, lattice girders, under rails continuous over two 168 ft. openings, 22.5ft. deep, 16 ft. apart; floor and wind screen as

*Paper read before the British Association at Montreal.

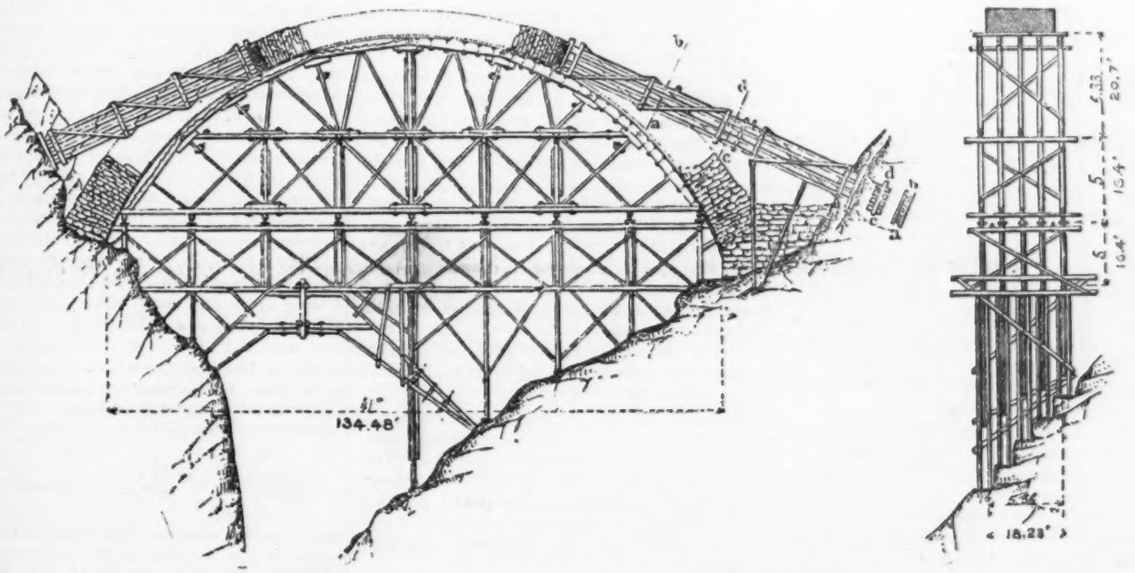


FIG. 2.—THE WALDLITOBEL VIADUCT, CENTERING AND ARCH CONSTRUCTION.

for internal viaduct. Masonry piers 25 ft. by 8 ft. at top, and 50 ft. by 20 ft. at base.

Rolling load: (1) trains of unlimited length on each line of rails, weighing one ton per foot run; (2) trains on each line made up of two engines and tenders, weighing in all 142 tons, at the head of a train of sixty short coal trucks of 15 tons each.

Wind. A pressure of 56 lbs. per square foot, striking the whole or any part of the bridge at any angle with the horizon, and acting square or obliquely upon an area equivalent to twice the plane surface of the front girders, with a deduction of 50 per cent. in the case of tubes. The total wind pressure so derived amounts to 2000 tons on the 1700 ft. span, and 7900 tons on the whole superstructure included between the two cantilever end piers. The following table shows the magnitude and intensity of the heaviest resultant stresses in tons on some of the principal members from dead load, live load, and wind, distributed as already described:

| | Dead | | Live | | Wind | | Total | |
|---|---|---|---|---|---|---|---|---|
| | Gr Str | Stress per sq. in. | Gross Stress. | Stress per sq. in. | Gross Stress. | Stress per sq. in. | Gross Stress. | Stress per sq. in. |
| Bottom member | 2282 | 2.8 | 1022 | 1.2 | 2920 | 3.5 | 6224 | 7.5 |
| Top " | 2253 | 4.4 | 997 | 2.0 | 541 | 1.1 | 3794 | 7.5 |
| Vertical " | 1550 | 3.3 | 705 | 1.5 | 1024 | 2.2 | 3279 | 7.0 |
| Diagonal struts | 802 | 4.1 | 167 | 0.8 | 414 | 2.1 | 1383 | 7.0 |
| " ties | 754 | 4.6 | 186 | 0.2 | 194 | 1.2 | 1134 | 7.0 |
| Hor. wind bracing | 80 | 0.9 | 5 | 1. | 265 | 3.0 | 350 | 4.0 |
| Ver. " " | 42 | 0.5 | 169 | 2.0 | 108 | 1.3 | 319 | 3.8 |
| Central girder top | 337 | 2.4 | 304 | 2.2 | 182 | 1.4 | 822 | 6.0 |
| Cent. girder bottom | 330 | 2.3 | 301 | 2.1 | 247 | 1.8 | 878 | 6.2 |

Owing to the batter of 1 in 7½ of the main girders and the adoption of double piers, not merely at Inch Garvie, but for the main piers on either side of it, the calculation of stresses involves some interesting and complicated problems. It is fortunate that from the nature of the ground no unequal settlement can occur in the foundations or some of the stresses would be indeterminate by reason of the double piers, which, I may add, were not a feature of the original design.

At the center cantilevers any unequal loading is supported by the double bracing between the piers at Inch Garvie, but at the north and south cantilevers the support is twofold, namely, the resistance of the bracing, and the pull on the holding-down bolts at the cantilever end pier. The first problem that arose, therefore, was to ascertain how much of the load would be supported by each of these reactions.

But the weight of each part was not known, and in a structure of this magnitude it required to be ascertained with accuracy. This could only be done by the method of trial and error, and as the stresses produced by the weight of the structure itself are very considerable, and at the secondary bracing is an important item, detailed drawings had to be made and carefully measured several times before the stresses could be determined. The inward slope of the cantilever gave rise to forces of sensible amount from the component of the vertical forces square to the plane of the cantilevers. A much more difficult problem, however, was presented by the stresses produced by wind. Thus, for example, a force acting horizontally on the cantilever near the 350 ft. girder, and at right angles to it, produces at the main pier a downward pressure on the leeward side, and an upward action on the windward side, together with a twisting action, and vertical and lateral pressures on the cantilever end pier. All these forces had to be traced through the different members and bracings, and the same had to be done for a wind force acting as a moving load at every point of the cantilever. It was also essential to consider the wind as blowing not only at right angles to the line of the bridge, but also at such other angle as would impose on each member the greatest amount of stress. It will be readily seen that the stresses produced by wind are very severe, and, therefore, exactness was required in order that no part might be unnecessarily heavy, nor on the other hand be strained beyond the allowed amount. After all the stresses as a framework structure arising from the dead load, a travelling train, and from wind had been ascertained, a new set of problems arose, chiefly from the magnitude of the work, and the weights of the different members themselves which cause local stresses of considerable importance in some instances.

An all-important point was, of course, the stress per square inch admissable upon the several tension and compression members. The only limit practically imposed upon us by the Board of Trade was that the stress should not exceed one-fourth of the ultimate strength of the steel without reference to the question of the relative proportions of live and dead load, or the character of the stress. In settling the sectional areas we did not bind ourselves to any formula derived from Wöhler's or other experiments on the fatigue of metals, but considered each member separately and had reference to the whole of the circumstances, including the character of the rivetting and other details of construction. As many competent engineers are of opinion that the rational way of proportioning structures is to assume varying ultimate resistances of the metal for the different proportions of dead and live load, and adopt an uniform factor of safety of 3, we tested the actual areas of the Forth Bridge members by the following rules, and found in all cases an excess on the requirements.

*a.* For a constant load assume the ultimate tensile strength to be 30 tons per square inch.

*b.* For a load varying from *nil* to a maximum assume the strength to be 20 tons per square inch if the alternation of stress is frequent, and 22.5 tons if it is seldom, as in the case of a hurricane.

*c.* For alternate tension and compression assume the ultimate strength to be 10 tons if frequent and 15 tons if seldom.

The above apply to tension members, and are to be divided by 3 for the working stress. For struts the working stress equivalent to the above, from the results of my own experiments and from other considerations, I take to be 40 per cent. of the stress causing first flexure, as given by the following empirical formulæ:

$$f = (.44 - .002\,r)\,(t + 18) \text{ for tubes.}$$
$$f = (.40 - .004\,r)\,(t + 18) \text{ for lattice.}$$

where $r$ ratio of length to diameter and $t$ =tons per square inch, as set forth in paragraphs *a*, *b*, and *c*, but increased in all cases in the ratio of 34 to 30, which are the specified minimum strengths of the steel used for compression and tension members respectively.

I have no doubt that any structure proportioned by the above rules would have an ample margin of safety, but as already stated the stresses in the case of the Forth Bridge are lower than indicated. The diagram of stresses shows that the lower tubular member is the most effected by wind, and, in fact, under the conditions assumed the leeward tube does the work and the windward is almost relieved of stress. Looking at the huge 12 ft. tubes as they now lie at the Forth Bridge works, with their ten longitudinal T bars 12 in. by 7 in. by ⅞ in., having double angles rivetted to the web of the T, and with annular stiffeners every 8 ft., certainly nothing could appear better adapted to resist stress and fatigue, and I should not feel the least anxiety if they were subject to double the stress which will ever be imposed upon them. I may add that the preceding formula for struts is based upon my experiments with steel ranging from 26 to 56 tons in tensile strength, and fairly represents the average results, though in this instance, as in all others where columns are concerned, individual experiments differ rather widely, owing to initial stress, unequal bearing, or other cause. In proportioning the rivetted joints of the tubes and other members, the shearing area is generally made one and a half times the net sectional area of the plates connected if in tension, and half that for planed and butted joints in compression only.

In my first paper I said that the maximum wind pressure upon the 1700 ft. span had been assumed to be equivalent to a pressure of 56 lb. per square foot upon the double surface, and I regretted that such assumption necessarily involved many matters of pure conjecture, which rendered it impossible to state with precision what factor of safety would belong to the Forth Bridge. The same remark of course applies even now with equal force to every other bridge, because there exists a lamentable lack of data respecting the actual pressure of the wind on large structures. Mr. Fowler and I have spared no pains during the past two years to contribute something to the general fund of information; and other engineers, doubtless, are experimenting—for experiments, and not speculations are wanted. We have had now for two years, on the island in the middle of the Forth near the center pier of the bridge, three wind gauges or pressure boards; the large one, 300 sq. ft. in area, is fixed square to the east and west winds, and of the two small ones of 1½ sq. ft. area, one is fixed as above, and the other is free to swivel square to the wind in any direction. When speaking at the Institution of Civil Engineers on the subject of wind pressure, previous to the erection of these gauges, I ventured to prophesy that, contrary to the opinion of many, the large board would show a smaller average pressure per square foot than the small ones. I have summarised the readings of the gauges for the past two years, and find them to fairly bear out my anticipations. In preparing the following table, the mean of all the readings of the revolving gauge between 0 lb. and 5 lb., 5 lb. and 10 lb.. etc., have been taken, and the mean of the corresponding readings at the same time of the small fixed gauge and of the large fixed gauge for easterly and westerly winds have been set forth opposite.

| Revolving Gauge. | | Small Fixed Gauge. | | Large Fixed Gauge | |
|---|---|---|---|---|---|
| Mean Pressure. | | Easterly. | Westerly | Easterly | Westerly. |
| lb. | lb. | lb. | lb. | lb | lb. |
| 0 to 5 | 3.09 | 3.47 | 2.92 | 2.04 | 1.9 |
| 5 to 10 | 7.58 | 4.8 | 7.7 | 3.54 | 4.75 |
| 10 to 15 | 12.4 | 6.27 | 13.2 | 4.55 | 8.26 |
| 15 to 20 | 17.06 | 7.4 | 17.9 | 5.5 | 12.66 |
| 20 to 25 | 21.0 | 12.25 | 22.75 | 8.6 | 19 |
| 25 to 30 | 27.0 | .. | 28.5 | .. | 18.25 |
| 30 to 35 | 32.5 | .. | 38.5 | .. | 21.5 |
| Above (One observation only above 32.5.) | 65 | .. | 41.0 | .. | 35.25 |

I do not myself, nor does Mr. Fowler, place implicit faith in the registrations of our own or anybody else's anemometers, although we test the working of the gauges in the most careful manner, but at the same time I think it is pretty well established by our two years' experiments, that the effective pressure per square foot on a large and comparatively heavy board averages only about two-thirds of that indicated by an ordinary light anemometer. It will also be noticed that the heaviest gales have been from the west, and that the revolving gauge then indicated much the same as the fixed gauge. Some critics were of opinion that our 300 ft. gauge would be of little use, as it could not swivel square to the wind, but remembering the experiments made with a fan blast on oblique plates which showed that the resultant pressure was normal to the surface, I felt sure that having reference to the prevailing winds swivelling was of no practical importance at the Forth, and the results justified my anticipations.

[TO BE CONTINUED.]

Detail of Bids for Sections "A" and "B," New Croton Aqueduct, Opened October 29, 1884.

| No. | NAME OF BIDDER. | EXCAVATION. Per Cubic Yard. Rock. a | Earth. b | Soiling. c | Tunnel d | Per Linear Ft. Shaft. Large e | Small f | MASONRY. Per Cubic Yard. Brick g | Concrete h | Rubble Stone. i | Additional Cut Stone j | Cement Portland k | American p | SHAFT FILLING. Per cu. yd. q | DRAINS. Per Linear Foot. Excavation & Maintenance of Drains r | 6 in. s | 8 in. t | 10 in. u | 12 in. v |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Section "A"** | | | | | | | | | | | | | | | | | | |
| 1 | Douglass, Dalzell & Douglass | 2 | 85 | 75 | 8 85 | 78 | 70 | 13 50 | 6 80 | 6 50 | 7 75 | 30 | 1 50 | 75 | 75 | 80 | 1 | 1 20 | 1 35 | 1 60 |
| 3 | Arnold, Gere & Stevens | 3 | 50 | 50 | 10 25 | 75 | 25 | 13 | 7 | 7 50 | 7 | 20 | 1 | 1 | 1 | 80 | 50 | 7 | 1 | 1 25 |
| 5 | Henry Collins (Detroit) | 3 25 | 60 | 75 | 6 94 | 145 40 | 95 | 9 95 | 4 23 | 5 50 | 2 50 | 40 | 2 50 | 1 50 | 1 25 | 80 | 15 | 20 | 30 | 38 |
| 7 | Hamilton Smith, Jr | 2 | 1 50 | 40 | 11 50 | 80 | 80 | 13 75 | 7 50 | 8 50 | 6 | 30 | 2 | 1 20 | 1 50 | 80 | 45 | 45 | 50 | 60 |
| 9 | Clark & Donovan | 2 50 | 40 | 50 | 6 00 | 130 | 80 | 12 | 5 | 6 | 5 | 50 | 2 | 3 | 30 | 2 | 20 | 30 | 40 | 80 |
| 11 | John Cox & Co., Chicago | 5 98 | 65 | 80 | 6 09 | 160 43 | 145 93 | 13 | 5 90 | 6 75 | 6 21 | 65 | 2 45 | 1 50 | 75 | 1 04 | 80 | 1 | 1 20 | 1 40 |
| 13 | Brown, Howard & Co., New York | 2 50 | 1 50 | 75 | 6 75 | 75 | 75 | 13 | 8 | 9 | 10 | 60 | 2 50 | 1 | 75 | 1 50 | 25 | 35 | 45 | 55 |
| 15 | Malone, McGrann & Co., Lane, Pa | 2 | 50 | 60 | 7 75 | 100 | 80 | 10 75 | 5 50 | 6 | 5 | 40 | 1 75 | 1 25 | 75 | 1 50 | 50 | 60 | 75 | 1 |
| 17 | John B. Devlin, New York | 50 | 20 | 10 | 5 | 42 71 | 45 | 9 04 | 4 37 | 5 | 6 30 | 40 | 1 50 | 1 25 | 15 | 50 | 25 | 40 | 65 | 80 |
| 19 | Swift & McNamee | 2 | 50 | 1 | 7 50 | 80 | 60 | 13 | 6 | 7 25 | 8 | 50 | 2 50 | 1 | 1 | 50 | 30 | 30 | 45 | 60 |
| 22 | Rutter, Ripley & Co | 2 | 1 | 90 | 9 50 | 65 | 65 | 14 | 7 | 8 | 7 | 35 | 2 | 1 25 | 60 | 2 50 | 45 | 60 | 85 | 95 |
| 14 | Weber & Wendt, New York | 1 50 | 40 | 60 | 7 47 | 80 | 80 | 14 | 5 | 5 50 | 6 | 67 | 1 25 | 75 | 1 | 2 | 30 | 45 | 70 | 80 |
| 26 | Jno. O'Brien, New York | 1 40 | 35 | 50 | 7 50 | 72 80 | 50 | 7 | 5 | 5 50 | 5 | 20 | 50 | 30 | 1 | | | | | |
| 28 | M. S. Coleman | 3 | 1 | 1 | 9 75 | 90 | 75 | 14 | 10 | 10 50 | 10 | 30 | 50 | 50 | 1 | 2 | 1 50 | 1 50 | 1 50 | 1 50 |
| | **Section "B"** | | | | | | | | | | | | | | | | | | |
| 2 | Douglass, Dalzell & Douglass | 2 | 80 | 75 | 8 48 | 74 | | 13 | 6 60 | 6 50 | 7 75 | 30 | 1 50 | 75 | 75 | 80 | 1 | 1 20 | 1 35 | 1 60 |
| 4 | Arnold, Gere & Stevens | 3 | 50 | 50 | 10 25 | 75 | | 13 | 7 | 7 50 | 7 | 20 | 1 | 50 | 1 | 88 | 50 | 75 | 1 | 1 25 |
| 6 | Henry Collins, (Detroit) | 3 99 | 58 | 75 | 6 73 | 145 40 | | 9 95 | 4 23 | 5 59 | 2 50 | 40 | 2 50 | 1 50 | 1 25 | 80 | 15 | 20 | 30 | 38 |
| 8 | Hamilton Smith, Jr | 2 | 1 50 | 40 | 11 50 | 80 | | 13 75 | 7 50 | 8 50 | 6 | 30 | 2 00 | 1 20 | 1 50 | 50 | 45 | 45 | 50 | 60 |
| 10 | Clark & Donovan | 2 50 | 40 | 50 | 6 | 130 | | 12 | 5 | 6 | 5 | 50 | 2 | 3 | 30 | 2 | 20 | 30 | 40 | 80 |
| 12 | John Cox & Co | 6 98 | 85 | 80 | 6 00 | 160 50 | | 13 60 | 5 90 | 6 75 | 6 21 | 65 | 2 45 | 1 50 | 75 | 1 04 | 80 | 1 | 1 20 | 1 40 |
| 14 | Brown, Howard & Co | 2 50 | 1 50 | 75 | 6 75 | 75 | | 13 | 8 | 9 | 10 | 60 | 2 50 | 1 | 75 | 1 50 | 25 | 35 | 45 | 55 |
| 16 | Malone, McGrann & Co | 2 | 50 | 60 | 7 75 | 100 | | 10 75 | 5 50 | 6 | 5 | 40 | 1 75 | 1 25 | 75 | 1 50 | 50 | 60 | 75 | 1 |
| 18 | John B. Devlin | 50 | 20 | 15 | 5 10 | 42 17 | | 9 08 | 4 37 | 5 | 6 30 | 40 | 1 50 | 1 25 | 10 | 50 | 25 | 40 | 65 | 80 |
| 20 | Swift & McNamee | 2 | 50 | 1 | 7 50 | 80 | | 13 | 6 | 7 50 | 8 | 50 | 2 50 | 1 | 1 | 50 | 30 | 30 | 45 | 60 |
| 21 | Ward, Mackin & Co | 2 50 | 1 | 75 | 8 90 | 95 | | 11 | 6 | 7 | 5 | 50 | 1 00 | 50 | 1 | 80 | 50 | 60 | 75 | 1 |
| 23 | Rutter, Ripley & Co | 2 25 | 1 | 90 | 9 | 65 | | 14 | 7 | 8 | 7 | 35 | 2 00 | 1 25 | 60 | 2 50 | 45 | 60 | 85 | 95 |
| 25 | Weber & Wendt | 1 50 | 40 | 60 | 7 50 | 80 | | 14 | 5 | 5 50 | 6 | 67 | 1 25 | 75 | 1 | 2 | 30 | 40 | 70 | 80 |
| 27 | John O'Brien | 1 40 | 35 | 50 | 7 | 72 80 | | 7 | 5 | 5 50 | 5 | 20 | 50 | 30 | 1 | 50 | 50 | 60 | 75 | 1 |
| 29 | M. S. Coleman | 3 | 1 | 1 | 10 | 90 | | 14 | 10 | 10 50 | 10 | 30 | 50 | 50 | 1 | 2 | 1 | 1 | 1 50 | 1 50 |

## WATER.

DENVER, Colorado, is rigidly enforcing the law in regard to waste of artesian well water; fines and, in one case, imprisonment are inflicted on the violators of the ordinance.

THE second artesian well at Greeley, Col., which had reached a depth of 1,200 feet, required a dynamite explosion to make the flow satisfactory. This was done by Messrs. Swan and Brothers, contractors, with satisfactory results. The shot consisted of 100 pounds of nitro-glycerine.

LOGAN, Iowa, now has fine water-works. A tank holding 3,500 barrels has been built on the high hill, just west of town. A wind mill is used to pump the water from a well near the tank. Pipes and hydrants supply the water throughout the town.

THE Water-works of Elkhart City, Ind., were officially tested on October 21st. The Water & Gas Construction Co., of Pittsburg, Pa., were the contractors, and Geo. R. Harlow engineer for the contractors. The supply is obtained from a well 30 ft. in diameter, sunk along side the Christiana Creek; the well contains 24 ft. of water. The pumps and boilers are furnished by Fairbanks, Morse & Co., of Chicago, Ill. The engines may be worked together or separately and have a capacity of 4,000,000 gallons in 24 hours. The domestic pressure is 40 lbs., and the fire service 140 lbs.

The official test was very satisfactory, exceeding the contract specification of five fire streams of 100 ft. height each. The local authorities especially compliment the builders of the work upon the unusual feature of completing their contract two months ahead of the specified time.

## NEWS OF THE WEEK.

### Miscellaneous.

OWING to high water the work of dredging the ice harbor at Dubuque, will not be begun this fall.

THE contract for building a stone jail at Abilene, Texas, has been awarded to M. F. Shannon & Co., for the sum of $12,877.

THE last span of the Chicago, Rock Island and Pacific bridge over the Rock River, has been completed.

TENDERS are being prepared for building a $3,000,000 bridge over the St. Lawrence at Lachine for the Canadian Pacific railway.

THE Goss Iron Works of Bath, Me., have just completed a marine engine to run on the triple expansion principle. This is the first one of that class built in America.

THE long wooden bridge crossing the Schuylkill River at the foot of Penn Street Reading, Pa., is being torn down to give place to an $80,000 iron bridge to be completed by next May.

THE examiners of the patent office have rendered their decision in the telephone contest of Voelker vs. Gray et. al. sustaining the priority of Bell's inventions on nearly all the leading points.

THE bridge of the Wisconsin Central R. R. at Chippewa Falls, Wis., is nearly completed. It will replace one carried away by the floods. The stone work of the bridge near Stillwater is finished and the iron work well advanced.

BIDS for furnishing materials for a new laundry on Hart's Island will be received by the Department of Charities until Nov. 8. Lumber, iron and cement are among the items. For further particulars see *City Record* of Oct. 27, and following.

NEARLY 300 men are employed in the ordnance department of the Philadelphia Navy Yard upon the guns for the new steel cruisers. These are four sizes, five inch bore by twelve feet six in length, six by fifteen, eight by twenty and ten by twenty-six.

BRIDGE BUILDING IN BOHEMIA.—An iron bridge has just been replaced by one of later construction on the North Bohemian Railway, near Kuttenthal. At the point in question the line crosses a ravine, 98 ft. deep. The span of the bridge was 131 ft. 2 in.; the weight of the truss 80 tons. The method of reconstruction adopted was to erect each bridge span upon rollers, and then, by means of a locomotive, to pull it above the place it was to occupy on the top of the old bridge. The span was then raised by hydraulic jacks and the rollers removed. As soon as the old bridge was removed the new truss was lowered a distance of 15 ft. to its final bearing upon the piers. Trains were stopped during the operation of substituting the new truss, but the total period of stoppage was less than forty-eight hours.

CHESTER, Oct. 29.—The road between this city and Media promises to be a success. A number of Chester capitalists, among the number being H. B. Black, George B. Lindsay, B. F. Baker, Samuel H. Seeds, Hugh Shaw and Robert Wetherhill, headed by E. Mitchell Cornell, superintendent of the Street Railway Company, have arranged for a preliminary survey, which will take place next week, under the supervision of J. B. Wingate, civil engineer, of Philadelphia. It is proposed to build a narrow-gauge road, of steel rails, the cars to be dummy engines, which will be run at regular intervals during the day, stopping to take on or let off passengers at any points along the road. The line can be constructed for less than $150,000. A temporary organization has been effected by the election of E. Mitchell Cornell, president; George B. Lindsay, secretary; Samuel H. Seeds, treasurer, with a committee of five on points survey.

AT a recent meeting of the directors of the Highland Junction and Storm King Bridge company, which was organized in 1881 to build a bridge across the Hudson river at Storm King mountain, about midway between New York and Albany, it was resolved to at once put the surveys and plans of the bridge in shape and invite proposals for the building of the bridge.

THE improvement of the river front at Memphis, Tennessee, is in a fair state of progress. Willow and pole mattresses, bound with wire and laden with rock, have been sunk from above the mouth of Wolf River to near the head of the paved landing at the foot of Jefferson street. At several points two mattresses have been put down, one on top of the other. The appropriation of $200,000 secured from the last Congress for this work will, it is estimated, be sufficient to place mattresses along the river front from Wolf River to the foot of Linden street.

AN engine, probably the smallest in the world, has been made by a watchmaker now connected with a watch manufacturing company. As described, the engine is of the upright pattern, and is made of steel and gold. It rests on a 25 cent gold piece, and can be worked either by steam or compressed air. The cylinder is a little less than 1-16 of an inch in diameter, with a little less than 3-32 of an inch stroke. The balance wheel is 1-3 of an inch in diameter and can make something like 1,000 revolutions a minute. The wristpin is a sapphire cut for the purpose.

THE gulf stream, as is shown by comparisons made in the London Meterological Office, was about three degrees above the mean during June last, and from a degree to one and a half degree above during July and August, from the European coasts almost to the mid-Atlantic meridian. This leads the New York *Herald* to suggest that "possibly the bright red sunsets which have reappeared this autumn on both sides of the North Atlantic may be an effect of the diffusion of oceanic evaporation in excess, consequent upon the undue heating of the intertropical seas."

DR. ARON has succeeded in manufacturing artificial graphite. He exhibited at the meeting of the Berlin Electrical Society, various specimens of vegetable carbon, which were made conductors and rendered almost incombustible by energetic and prolonged heating in a vacuum or in a neutral atmosphere. These properties are so much like those of graphite that the product may well be called artificial graphite, although it is not crystalline. The experiments show that if, as has been affirmed, the presence of hydrogen in graphite determines its combustibility, this can be true only of combined hydrogen, for carbon which has been calcined and made incandescent in an atmosphere of hydrogen is no more combustible than before.

THE contract for constructing jetties at Volusia Bar, Lake George, was awarded Oct. 24, to C. F. Hopkins and J. F. Le Baron of Jacksonville, Fla., engineers and contractors, by the U. S. Engineer Department.

S. P. ENSIGN, Lime Rock, Ct., invites proposals for a Double Track, Iron, Highway, Bridge of about 154 ft. span to be built across the Housatonic River near Lime Rock.

THE following is an abstract of the proposals to furnish a steam boiler for the U. S. Steam Tug on Cape Fear River, opened October 24th by Col. W. P. Craighill of the U. S. Engineers. No. 1, price delivered at Wilmington, N. C., No. 2, price delivered at most convenient place for the bidder, and put in tug complete. James Clark & Co., Baltimore, No. 1, no bid; No. 2, $1290. E. J. Codd & Co., Baltimore, No. 1, $1592. No. 2, $1742. Warden & Mitchell, Philadelphia, No. 1, $2500. No. 2, no bid. Columbian Iron Works & Dry Dock Company, Baltimore, $1500 delivered on their wharf. John C. Froehlich & Co., Baltimore, No. 1, no bid; No. 2, $1330. J. P. Morris & Co., Philadelphia, No. 1, $1450. No. 2, $1530. Robert M. Spedden, Baltimore, No. 1, $1347,50. No. 2, $1345. Burr & Bailey, Wilmington, N. C., No. 1, $2200. No. 2, $2500. Samuel W. Skinner, Wilmington, N. C., No. 1, $1950. No. 2, $2500. The Pusey & Jones Company, Wilmington, Del., No. 1, $2460. No. 2, 2460. Theo. Smith & Bro., Jersey City, No. 1, $1650. No. 2, no bid.

### Railroads and Canals.

CAPT. EADS Ship Railway exhibition is booked for New York and the New Orleans Exposition.

THE engineer party of the Chicago, Freeport & St. Paul, has reached Arepyle, Wis., a distance of 40 miles.

THE Philadelphia & Norfolk road is within 3 miles of its Southern terminus.

THE survey of the projected Chesapeake and Nashville railroad has been commenced at Nashville. The work is being carried on by Engineer Childs.

ON October 20, the 59 miles of the Canadian Pacific west of Sudbury Junction were accepted from the contractors.

THE Northern extension of the Milwaukee, Lake Shore & Western is now completed to Bessemer, Ontonagon county, Mich., 345 miles from Milwaukee.

THE South Florida road, which extends from Sanford to Tampa, is now actively pushing an extension southward to Barton.

SURVEYORS are at work running a line for a railroad from Reading to Lebanon, there to connect with Robert Coleman's Road to the Pennsylvania Railroad.

OCTOBER 25, the Minneapolis and St. Louis road was completed to within fifteen miles, and the Burlington to within eighteen miles of Watertown.

THERE is less railroad construction now going on in Indiana than in any year since 1847, when the first road in the State, the Madison & Indianoplis, was completed.

THE Maryland and Delaware Ship Canal project will be pushed in the next Congress. The Southern route terminating in the harbor formed by the Delaware breakwater is prefered.

SURVEYORS for the Wabash St. Louis and Pacific road are at work in the vicinity of Alton to determine upon a poi t to build a bridge across the river. The survey lays near the head of Bayless Island.

THE Dublin & Wrightsville is a proposed road from Dublin to Wrightsville, Ga. At the latter place it is proposed to connect with the Wrightsville & Tennille road. Considerable money has been contributed in aid of the enterprise.

THE Missouri River & Northern, recently chartered, is to run from Valley City, Barnes county, through La Moure, Brown, McPherson, Edmunds, Faulk, Potter, and Sully counties to Pierre, in Hughes county. Connection is to be made with the Northern Pacific at Valley City.

IT is said that there is no doubt that a railroad will be built from Montrose to Ouray, connecting the latter place with the Denver and Rio Grande system. The contract is already let for the grading, and work will probably soon begin.

THE Government of the United States of Columbia has informed the Panama Railroad Company that it will not allow that company's lines of railroad to be cut, changed or damaged for the benefit of the De Lesseps Canal.

OPERATIONS have almost been suspended on the Topeka, Salina & Western R. R. at present. A force of graders are throwing dirt in Dickerson county, and have proceeded with the grade to Hope Center, about 35 miles west of Council Grove, but aside from that there is nothing doing.

A COMPANY has been organized under the name of the St. Louis, Topeka and North Western to build a road from Topeka, Kan., to the coal fields of southeastern Missouri. The following are the directors: John T. Francis, M. T. Sullivan, J. G. Stonaker, Topeka; Joel Moody, Mound City, Kan.; F. Eggers, Appleton, Mo.: Chester Bullock, New York. The officers are: President, John I. Francis; Secretary, M. I. Sullivan; Treasurer, F. Eggers.

THE Sheffield & Seaboard R. Co. has been incorporated to build from Sheffield, Ala., to the Mississippi line. Coal and iron mines will be sought by the main line and by branches. O. O. Nelson, Montgomery, Ala.; C. A. Collier, Atlanta, Ga.; A. H. Moses, Sheffield, Ala.; David Krauss, Huntsville, Ala.; and C. C. Harris, Decatur, Ala., are leading incorporators. The same parties have incorporated the Sheffield & Nashville R. Co., to build from Sheffield to the Tennessee line.

HUNTINGTON, Oct. 24.—The branch of the East Broad Top Railroad, now in course of construction from Orbisonia, this county, to Burnt Cabins, Fulton County, where it will connect with the South Pennsylvania Road, is completed to Shade Gap, with the exception of a bridge over a small stream to be finished within a week. This branch, like the road to which it is tributary, is of the narrow gauge, but the road bed and bridges have been made wide, to permit it to be enlarged to the standard gauge at any time.

THE following railroads are now in course of construction or in contemplation in the State of Mississippi: The Warrior Coal Fields Railroad, from Aberdeen to the coal fields of Alabama; the Mississippi River & Deer Creek Railroad, from Carolina Landing to Deer Creek; the Gulf & Ship Island Railroad, from Jackson to Mississippi City; the New Orleans & Northwestern Railroad, from Natchez towards New Orleans; the Georgia Pacific Railroad, from Greenville to Columbus, and the branch road from Yazoo City to Memphis, being a continuation of the Illinois Central Railway.

WORK is advancing on the Dakota Midland. Twenty miles of grading have already been done in Sergeant and Richland counties, and graders are now at work at Campbell, Wilkin county. The Dakota Midland will cross the Manitoba at this point. The eastern division of the road from the Missouri at a point twenty miles south of Fort Yates to Campbell has been located, and contracts for grading the same have been let. It is the intention of this company to complete this portion of the road as soon as possible. The charter calls for an extension of the road to Duluth, but no work will be done beyond Campbell for some little time.

ARRANGEMENTS are being made for an extension of the Northern Pacific company's Livingstone branch from Cinnabar to the Yellowstone Park hotel, a distance of six miles. Two miles of the line have been graded ready for track-laying and bridge building for some time, but work was suspended on account of some trouble in getting the right of way. Work will, however, be commenced in the spring, and it is hoped by the summer of 1886 the line will be completed. To build the line a tunnel will have to be made through the mountain a mile long. The government has now begun a new line from the Park hotel, tunneling the great Cathedral rock in the geyser basin, which will shorten the route now in use about six miles. At the end of the line a new government hotel will be built, work on which has begun already.

A CURIOUS accident checked the traffic on the railroad across the Brooklyn Bridge, for a half hour on the evening of Oct. 22. When the heaviest traffic occurs, nine trains of two cars each are kept running It happened that five of these were east of Brooklyn's tower at one time. As the grade is something over a 100 ft. to the mile, the effect of this was to bring all the slack of the cable at the east end where it coils around the driving drum. The combination of the above with the circumstance that the cable had been given its periodical coating of tar and oil on that day, and was wet from the falling rain caused it to slip on the drum and matters came to a standstill. On the arrival of Superintendent Martin upon the scene, he ordered all the cars on the eastern grade to let go and run back into the station. The cable then took hold of the drum again, and traffic was renewed.

IN a report to the directors of the North British Railway, dated August 20, Messrs. Barlow and Son, the engineers of the New Tay Bridge say: During the past half year the cylinder foundations of 14 piers have been put in. The total number of piers whose foundations are in, is 498, leaving 37 to be done. All the four pontoons are now at work sinking foundations. The operations of testing cylinders is now being carried on on both sides of the river with satisfactory results. The new girders for the esplanade at Dundee have been erected, and the erections of girders will continue from that point southwards. All the cofferdam work on both sides of the river has been completed. The piers for the arching at Wormit are built up to springing level, and the staging and centers for turning the arches are being fixed. The wrought-iron superstructures or shafts of piers are being proceeded with at Glasgow. The ironwork for the girders and flooring of the viaduct is well advanced, and a considerable portion has been delivere 1 at Dundee and Wormit.

CHEYENNE letter to Boston *Courier*: There is a vast bed of rock salt in the Colorado Desert, near Idaho; and the Southern Pacific Railroad in laying the track to the salt mine have been obliged to grade the road for 1,200 ft. with blocks of these beautiful lumps of salt crystals. This is the first instance of a railroad road-bed being laid and ballasted on salt, of which we have any knowledge. The sea that once rolled over this place dried up, and left a vast bed of salt about fifty miles in length. The quality is superb, and supply inexhaustible. Grasshoppers of enormous size and giant centipedes have been pickled in this chloride of sodium, and are to-day, after the lapse of centuries, in full size and perfection of shape. This vast salt-bed will be valuable to the reducers of ore in California, Arizona and New Mexico, and can be supplied in boundless quantities.

ARTICLES of incorporation of the Decorah, Rochester, and Red River Railway Company have been filed in the office of the Secretary of State of Minnesota. The principal place of business of the company is at Decorah, Iowa. The road is to be constructed from Decorah in a southeasterly and northwesterly direction, and is to extend to such points in Iowa, Minnesota, Wisconsin, Dakota, and Illinois to connect with other railways as the board of directors may decide upon. The capital stock is $5,000,000 divided into shares of $100, each of which is entitled to a vote. William H. Vallean is President; George W. Adams, Secretary; Hiram T. Horton, Vice-president; Reuben H. Wales, Treasurer, and John W. Booth, Andrew Nelson, and Elliott A. Knowlton directors of the company. Railroad officials in St. Paul state that the new incorporation is probably a plant of the Burlington, Cedar Rapids, and Northern, which has already entered Decorah, and probably intends to push onward to Minneapolis and St. Paul.

THE work on the Philadelphia Branch of the B. & O. R. R. near North East, Md., is progressing rapidly, and fast reaching completion. All of the masonry on the first residency of the Delaware Division which extends twelve miles east of the Susquehanna River, will be completed by December 1st. Sections 1 and 2 are now ready for iron work and track. At Principio Creek on Section 3 there is a large double arched culvert, consisting of two 30 ft. arches. This structure is 216 ft. long, and contains 6000 cubic yards of masonry, and will be completed by the middle of November. It is built entirely of Port Deposit granite, except the arch rings which are brick. This culvert passes under an embankment 72 ft. high and 1500 ft. long, containing over 200,000 cubic yards of material. On Section 4 and 5 the line passes over Foy's Summit, where there is a cutting nearly 3000 ft. long, and 66 ft. deep, at the deepest point. There are about 200,000 cubic yards in this excavation, a large portion of which has to be wasted. Messrs. Ryan & McDonald have the contract for these sections, and are working a steam shovel in each end of this cutting. Much trouble and delay to the work has been occasioned by the large amount of water that has been met with, making it impossible for horses to be used in bringing the cars up to the shovels. At the crossing of the Great North East Creek, there will be an iron viaduct 570 ft. long and 75 ft. high, consisting of fourteen 30 ft. and three 50 ft. spans. All of the masonry for this structure comprising forty-five pedestals, one pier and two abutments, has been completed by Messrs. Hand & Roland. At the west end of this structure is a U abutment containing 3000 cubic yards of masonry. Mr. S. P. Mitchell is the Resident Engineer in charge of this Residency, and Messrs. R. N. Hudson & B. B. Thornton the Inspectors of Masonry.